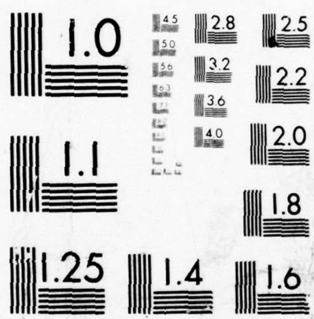
AD-A069 685 NAVAL RESEARCH LAB WASHINGTON DC SHOCK AND VIBRATION--ETC F/G 20/11
THE SHOCK AND VIBRATION DIGEST. VOLUME 11, NUMBER 5,(U)
MAY 79 J NAGEL-ESHLEMAN

UNCLASSIFIED NL

| OF |

AD
A069685

END
DATE
FILMED
7--79
DDC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

AD A069685

A067426

VOLUME 11, NO. 5
11 MAY 1979

3 2

LEVEL II

12 91p.

16

THE SHOCK AND VIBRATION DIGEST. Volume 11, Number 5,

A PUBLICATION OF
THE SHOCK AND VIBRATION
INFORMATION CENTER
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.

10 Judith Nagel-Eshleman

OFFICE OF
THE UNDER
SECRETARY
OF DEFENSE
FOR RESEARCH
AND
ENGINEERING

THE SHOCK AND VIBRATION DIGEST

Volume 11 No. 5
May 1979

A publication of

THE SHOCK AND VIBRATION
INFORMATION CENTER

Code 8404 Naval Research Laboratory
Washington, D.C. 20375

Henry C. Pusey
Director

Rudolph H. Volin

J. Gordan Showalter

Barbara Szymanski

Carol Healey

The Shock and Vibration Digest is a monthly publication of the Shock and Vibration Information Center. The goal of the Digest is to provide efficient transfer of sound, shock, and vibration technology among researchers and practicing engineers. Subjective and objective analysis of the literature are provided along with news and editorial material. News items and articles to be considered for publication should be submitted to:

Dr. R.L. Eshleman
Vibration Institute
Suite 206
101 West 55th Street
Clarendon Hills, Illinois 60514

Copies of articles abstracted are not available from the Shock and Vibration Information Center (except for those generated by SVIC). Inquiries should be directed to library resources, authors, or the original publishers.

This periodical is for sale on subscription at an annual rate of $100.00. For foreign subscribers, there is an additional 25 percent charge for overseas delivery on both regular subscriptions and back issues. Subscriptions are accepted for the calendar year, beginning with the January issue. Back issues are available by volume (12 issues) for $15.00. Orders may be forwarded at any time, in any form, to SVIC, Code 8404, Naval Research Laboratory, Washington, D.C. 20375. Issuance of this periodical is approved in accordance with the Department of the Navy Publications and Printing Regulations, NAVEXOS P-35.

SVIC NOTES

SYMBOLIC AND ALGEBRAIC MANIPULATION LANGUAGES

Most of the members of the shock and vibration community are not yet acquainted with the new techniques of symbolic and algebraic manipulation. Although most of us are familiar with the capacity of a digital computer to do numerical (digital!) calculations, few of us know that the data processing power of computers can now be applied to symbolic manipulation of formulas in mechanics. A good review of the activity in this area is that of Jarl Jensen and Frithiof Niordson of The Technical University of Denmark*. They describe in detail the following languages: ALTRAN, FORMAC, MACSYMA, REDUCE, SAC-1, SCHOONSCHIP, SCRATCHPAD, and SYMBOL.

The scientist or engineer who writes even small FORTRAN programs can benefit from knowing these newer techniques. The languages have been developed to aid man-machine communication, especially such programming languages as FORTRAN. With the newer techniques, the computer actively assists the programmer, for instance, in manipulating formulas. The present method is to write everything down on a FORTRAN coding form, have it punched, and then feed it into the machine. With a system such as MACSYMA, this process is shortened by the direct entry of formulas into the computer via an interactive terminal.

Certain problems in mechanics can be solved with standard numerical procedures, but more elegant and accurate solutions could be obtained with analytical methods if the formula work could be eliminated. Automated formula manipulation might afford the most effective solution to such problems.

Even though they can simplify programming procedures, these systems are not sufficiently utilized. Part of the problem is that engineers and scientists do not understand what these languages are and what they can do.

Any new technique must be manipulated before it can be applied to a specific technical area. The following examples illustrate a few of the types of problems that can be handled with symbolic/algebraic manipulation techniques:

- development of helicopter equations that require extensive coordinate transformations in symbolic form
- manipulation and solution of multi-variable systems of equations
- creation of approximations of functions with series expansions
- finding limits, computing integrals, preparing plots
- solving differential equations, taking Fourier and Laplace transforms

Much of this type of work could be done immediately at a keyboard.

In the future, we will surely see these systems available on desk-top minicomputers. For now time-sharing systems can be used. The bottom line, however, is always cost. But these systems will increase the speed and accuracy of problem formulation; thus they will certainly be cost effective.

J.G.S.

*Perrone, N., Pilkey, W., and Pilkey, B. (Eds.), "Structural Mechanics Software Series," Vol. 1, pp 541-576, The University Press of Virginia (1977).

EDITORS RATTLE SPACE

50th SHOCK AND VIBRATION SYMPOSIUM

In this issue of the DIGEST you will find information on the 50th Shock and Vibration Symposium. The Shock and Vibration Information Center (SVIC) will celebrate this event with a program especially planned to inform participants on the state of shock and vibration technology. The plan for this event is to examine the field of dynamics in retrospect as well as for future progress. As always, papers reflecting current progress in the shock and vibration field will be programmed. It is fitting for this special event to honor the founder of the Shock and Vibration Information Center -- Dr. Elias Klein. For this occasion the first Elias Klein Memorial Lecture will be presented at one of the Plenary Sessions by a person of stature in the engineering vibrations field.

In view of changing times there is cause to celebrate this event. The continued strength and popularity of the SVIC and its annual symposium reflects their ability to relate to the trends of the times. The first trend is to use technical information more effectively – less repetition and waste of engineering effort. The second trend is the increased demand on the shock and vibration engineer -- not only for better performing equipment but also for equipment built to accept more hostile environments. A third trend involves the process of getting more practical engineering information out of theory and practice.

I hope you will consider attending this event and/or offering a paper on your recent research and engineering efforts. The Symposium has always been strong on reporting the results of practical engineering work. Your continued attendance and support will enable the SVIC to continue this worthwhile event in future years.

R.L.E.

Announcement and Call for Papers

50th SHOCK AND VIBRATION SYMPOSIUM

A

GOLDEN COMMEMORATION

OF

TECHNOLOGY

Theme: Perspectives in Dynamics

Held at

Antlers Plaza Hotel

and

The U.S. Air Force Academy

Colorado Springs, Colorado
16, 17, and 18 October 1979

Host: The United States Air Force

Sponsor: The Shock and Vibration Information Center

CALL FOR PAPERS

50th SHOCK AND VIBRATION SYMPOSIUM
A Golden Commemoration of Technology

The theme of the 50th Shock and Vibration Symposium is Perspectives in Dynamics. The Symposium will be held at the Antlers Plaza Hotel and The U.S. Air Force Academy in Colorado Springs, Colorado on 16, 17, and 18 October 1979. The United States Air Force is the host for this meeting.

This meeting will be the 50th in a series of Shock and Vibration Symposia that began in January 1947. Although fifty years have not passed, it seems appropriate to commemorate this "golden" event with a program especially planned to inform the participants about the state of the shock and vibration technology. In effect, the plan is to examine the dynamics field in retrospect, to relate current capabilities to progress and to offer up shining examples of work that is breaking new frontiers. Perhaps it is also in order to take a peek at the future.

This announcement contains a program matrix tentatively established to cover the principal areas within the shock and vibration field. The program will include a limited number of invited papers, but very largely will consist of contributed papers selected to meet the program goals. It is these papers that will offer a realistic assessment of present capabilities and, indeed, present deficiencies. Authors offering papers are asked to keep the general theme in mind, to assist in making this symposium the most outstanding in the history of shock and vibration.

To honor the original architect for these symposia, we are announcing the first Elias Klein Memorial Lecture to be presented in one of the Plenary Sessions. Special efforts are being made to assure that the program will be well-rounded and informative. Other "specials" will be announced in the Advance Program.

For further information contact: The Shock and Vibration Information Center, Code 8404, Naval Research Laboratory, Washington, D.C. 20375 - Telephone (202) 767-2220 (Autovon 297-2220): Henry C. Pusey, Director; Rudolph H. Volin; J. Gordan Showalter; Barbara Szymanski; and Carol Healey.

SUBMISSION OF PAPERS

Those wishing to offer formal papers for the Symposium should carefully follow the instructions on the reverse side of the SUMMARY COVER SHEET (enclosed in this issue of the DIGEST). Papers may be offered either for presentation at the Symposium, or publication in the Bulletin, or both. Summaries of papers accepted for presentation will be published and distributed prior to the Symposium. Six copies of the two page (approximately 600 words) summary should be submitted. No figures should be included in the summary. Prospective authors are encouraged to submit supplemental figures and additional information which the program committee can use to evaluate the paper, but this material should not be referenced in the summary. Authors are required to furnish such a summary even if the complete paper is submitted. In general, unclassified-unlimited distribution summaries of classified papers are requested. If this is impossible a classified summary may be submitted, but this will not be published. Deadline for receipt of summaries is 25 June 1979.

CLASSIFIED SESSIONS

The Shock and Vibration Symposium provides a special platform and publication medium for authors of classified papers up to SECRET. To simplify problems of paper release, SVIC policy for the 50th Symposium is that attendance at classified sessions will be limited to U.S. citizens and others having the required clearance and need-to-know. Limited distribution papers which are accepted will likely be programmed in the classified sessions.

SHORT DISCUSSION TOPICS

This session is planned to allow progress reports on current research efforts and unique ideas, hints and kinks on instrumentation fixtures, testing, analytical short cuts and so forth. It is intended to provide a means for up-to-the-minute coverage of research programs and a forum for the discussion of useful ideas and techniques considered too short for a full-blown paper. These discussions will not be published. Accepted speakers will have 5 minutes for presentation and 5 minutes for discussion. Only unclassified-unlimited distribution discussions will be programmed for this session. Submittals should be made on the enclosed form by 10 September 1979. Acceptable presentations will be programmed as long as space is available.

EXAMPLES OF TOPICS FOR PAPERS

- Instrumentation
  - Unique Transducers
  - Special Measurement Problems
  - Measurement Techniques
- Data Analysis
  - Modal Test Data
  - Transient Data
  - Random Data

Dynamic Analysis
- Structure/Controls Interaction
- Media-Structure Interaction
- Nonlinear Analysis

Design Techniques
- Computer-Aided Design
- Design Analysis Procedures
- Design for Shock

Dynamic Properties
- Damping
- Fatigue

Application of Materials
- Isolation
- Energy Dissipation

Vibration and Acoustic Tests
- New Techniques
- Unique Facilities
- Criteria Development

Shock Tests
- Pyrotechnic Shock
- Seismic Tests
- Scaled Nuclear Simulation

CRITERIA FOR ACCEPTANCE

Papers will be evaluated on technical merit. They should describe work that advances the technology and which has not been published previously. Papers with a commercial flavor will not be accepted, however technical submissions from vendor employees will be judged without bias and on the same basis as those of other prospective authors.

PUBLICATION

For your scheduling, if your paper is offered for publication, three review copies of the complete paper, neatly typed in your own format, must be in this office by 10 September 1979. If the paper is accepted for publication, an author kit will be provided for final copy preparation. Acceptance for publication in the 50th Bulletin depends upon favorable referee review.

PROGRAM

The advance program for the Symposium will be distributed in September, together with hotel, security clearance, and registration information.

DATES TO REMEMBER

Deadline for Summaries: 25 June 1979
Paper Releases Due: 10 September 1979
Manuscripts for Review Due: 10 September 1979
Short Topics Due: 10 September 1979
50th Symposium: 16-18 October 1979

50th Shock and Vibration Symposium
Program Session Matrix

Tuesday, October 16th		Wednesday, October 17th		Thursday, October 18th	
Opening Session Keynote and Invited Speakers		ANALYSIS AND DESIGN Plenary: Invited Speaker		DYNAMIC TESTS Plenary: Invited Speaker	
		Dynamic Analysis	Design Techniques	Vibration and Acoustics	Shock
MEASUREMENT Plenary: Invited Speaker		MATERIALS IN DYNAMICS Plenary: Invited Speaker		Short Discussion Topics	Classified Session
Instrumentation	Data Analysis	Dynamic Properties	Applications		

SOME RECENT TRENDS IN AIRCRAFT FLUTTER RESEARCH

P.N. Murthy*

Abstract - ***This is a review of salient advances in the area of flutter since 1975. Trends in research and development are stressed. Only references considered relevant have been cited.***

In the past few years an intensive search has been underway for new concepts in aircraft design to meet stringent safety and operational demands made by the civilian sector. The energy crisis has added a new dimension. Reduction in d.o.c., lower specific fuel consumption, and larger payloads have motivated improved designs of commercial aircraft. Military requirements include greater maneuverability, multi-role capability, higher rates of climb, and larger pay loads. Design now involves a synthesis of materials, configuration, and power. Advanced engines, minimum drag airfoils, kinetic wing configurations, high wing loadings, and flexible structures are now common. Sophisticated designs have created interest in static and dynamic aeroelastic effects, and they now play a role in the design process from the start.

The two most important recent innovations in aircraft configurations have been oblique wings and control configured vehicles. The former resulted from research to reduce wave drag at transonic speeds; the latter was conceived to control aeroelastic instabilities by redistributing aerodynamic loads on lifting surfaces. The transonic speed range provides the maximum design challenge; such speeds tend to produce severe requirements on wing stiffness, pushing the flutter boundary as far as possible. Such instabilities as the buzz associated with oscillating shock waves occur. Active controls provide the best means for minimizing these instabilities.

OBLIQUE WINGS

It has been suggested [2] that oblique wings should replace conventional swept-back wings because the oblique wing substantially reduces wave drag at transonic and low supersonic speeds. Operation would be aerodynamically efficient throughout the envelope.

A simple analytical study of the flutter characteristics of the oblique wing was based on a three-degree-of-freedom model [3]. The mode of aeroelastic instability changed from static divergence to flutter when the wing was allowed to roll freely about the fuselage centerline. This behavior is typical of some structures subjected to nonconservative follower forces. Roll freedom resulted in a higher instability speed and changed the mode of instability. These results were confirmed in a sophisticated analysis [4].

The performance of two aircraft with oblique wing configuration -- a Boeing commercial Mach 1.2 airplane with 195-passenger capacity and a Lockheed-Georgia 200-passenger Mach 0.95 airplane -- has been compared. In the case of the fuselage-clamped oblique wing the critical mode is the divergence velocity of the swept-forward segment of the wing. As the wing sweep increases, the divergence velocity decreases, reaching a minimum at about a 40° sweep. When body roll freedom is allowed, flutter instability occurs in two mdoes: wing bending (also known as fixed root flutter), a torsional mode at low sweep angles ranging up to 30° and at a reduced frequency of 0.4; and a wing bending mode coupled with antisymmetric rigid body rolling motion (known as body freedom flutter) at a reduced frequency of about 0.04.

It was also found that when fixed root flutter is critical, a forward movement of the center of gravity of the wing improves the flutter condition. In any case body freedom flutter must be avoided because it occurs at low velocities and low frequencies. Another important result was that, for an aircraft which is geometrically unsymmetric with respect to

**Professor of Aeronautical Engineering, Indian Institute of Technology, Kanpur, India*

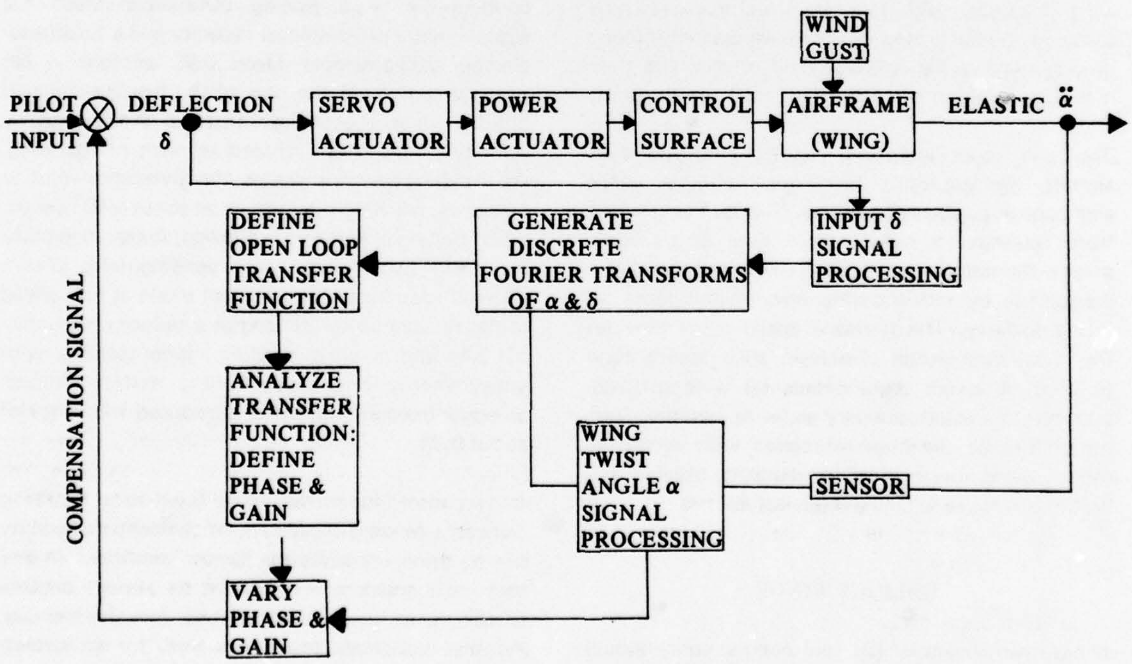
its roll axis, a structurally unsymmetric wing is useful. Increasing the bending stiffness of the swept forward wing by even 20 percent has little effect on the fixed root flutter velocity; the body freedom velocity is increased by 10 percent. On the other hand, increasing the torsional stiffness of the swept-back wing by 20 percent has little effect on the body freedom velocity; the fixed root velocity is increased. An increase in fixed root velocity without an increase in lower body freedom velocity is of little value; therefore, it was suggested that both torsional and bending stiffnesses of the swept-forward part be increased to increase body freedom velocities.

It can be seen that the wing roll moment of inertia relative to the fuselage roll moment of inertia is important. At low sweep angles the flutter behavior of both oblique and symmetric wings tends to be similar. At moderate sweep angles, however, oblique wing flutter is much like that of swept-forward wing divergence. Body freedom flutter speeds are much higher than the divergence speeds of symmetric swept-forward wings. A subcritical response study for the same aircraft indicated that body freedom instability is heavily damped until the onset of flutter.

ACTIVE CONTROLS

The capability of military aircraft modified to carry cargo must be increased. In such aircraft, flutter speeds can be within the flight envelope, thus reducing speed and performance. In such cases a passive flutter control system is not of much value. Instead, active controls -- that is, a situation in which aerodynamic control surfaces are activated by a system of sensors and feedback loops -- are used to change the loads and modes of deformation of the lifting surfaces. An active flutter control system must sense the flutter mode, compensate the feedback signal, and generate the necessary control surface force. The system senses the elastic mode response of a lifting surface to any excitation and compensates for any disturbance by changing the angle of attack. A typical scheme is shown below [6].

The transfer function of each element is generally selected so that stability of alternate configurations is achieved by altering only the feedback gain and pure phase-lag term. An ideal situation would be minimal phase lag and gain margins as altitude changes. The purpose of optimum flutter



suppression pole placement [7] is minimum controlling forces consistent with adequate overall gain and phase-lag margins. The control system would be designed to reflect feedback criteria for given design conditions. These laws could be varied in flight for effectiveness at other speeds. Feedback is affected by the power control unit rate limit; a design conditions. These criteria could be varied even when a control system is present.

It is sometimes difficult to obtain an accurate mathematical model for flutter; it may thus be necessary to use flight test data to calculate the required feedback criteria. The likely problems in modeling that create problems in the accurate determination of the relevant transfer functions include inaccuracies in the mathematical model for the modes used and the presence of modes not predicted.

Aerodyanmic Energy Technique

It has been suggested [8, 9] that aerodynamic energy methods be used in active flutter suppression. The objectives are to develop a control criterion involving both the leading and trailing edge control surfaces and to prevent extraction of energy from the air stream sufficient to overcome the inherent damping of the structure causing flutter.

A simple exposition [9] clarifies the principle. The work per cycle done by the wing while it undergoes bending and torsional oscillations is given by

$$\overline{W} = B_1 h_o^2 + B_2 \alpha_o^2 + B_3 \alpha_o h_o$$

- B_1 = damping in bending
- B_2 = damping in torsion
- B_3 = cross coupling damping
- h_o = amplitude in bending oscillations expressed by $h = h_o e^{i\omega t}$
- α_o = amplitude in torsional oscillations expressed by $\alpha = \alpha_o e^{i\omega t + \phi}$
- ϕ = phase difference between bending and torsion

These terms also contain the contributions of the control surfaces as given by the chosen control criterion. A linear transformation of h_o and α_o allows the cross coupling terms to vanish in many situations, so that $\overline{W}$ can take the principal quadratic form

$$\overline{W} = \lambda_1 h_1^2 + \lambda_2 \alpha_2^2$$

For a given geometry and location of the sensors λ_1 and λ_2 can be studied as functions of frequency of oscillation and a control criterion selected. If both λ_1 and λ_2 are positive, $\overline{W}$ must be positive, and flutter is not possible in the assumed modes. The entire design process thus depends upon choosing a control criterion and locating sensors so that λ_1 and λ_2 are positive.

The principle of active control can be explained through a mathematical model [9]. Assume for simplicity that all operators are linear; the basic equations of aeroelasticity can then be written in the form

$$([S] - [A] - [I])\{q\} = \{Q\}$$

- $[S]$ = structural operator
- $[A]$ = aerodynamic operator
- $[I]$ = inertial operator
- $\{Q\}$ = applied force vector
- $\{q\}$ = generalized coordinate vector

This can also be written in the form

$$[B_{ij}]\{q_{ij}\} = \{F_i\}$$

where

$$B_{ij} = \underbrace{(m_{ij} + a_{ij})\, p^2}_{\text{mass}} + \underbrace{(r_{ij} + b_{ij})p}_{\text{damping}} + \underbrace{(k_{ij} + c_{ij})}_{\text{stiffness}}$$

and $p = \dfrac{d}{dt}$

The quantities a_{ij}, k_{ij}, and c_{ij} are aerodynamic mass, damping, and stiffness terms respectively. They are functions of reduced frequency. F_i contains the active control forces due to each mode q_i resulting from the response of various sensor elements in addition to the usual excitation forces. The term F_i therefore incorporates the effects of the chosen control criterion through its transfer functions. To simplify the analysis, these transfer functions are ususally chosen as simple fractions of polynomial functions of p. These equations are solved for flutter conditions.

Alternative Approach through Control Theory

An alternative approach to active control of flutter suppression is state space methods of control theory [9]. The original differential equations of aeroelasticity given by

$$\underset{\text{mass}}{[M]\left\{\ddot{q}\right\}} + \underset{\text{damping}}{[B]\left\{\dot{q}\right\}} + \underset{\text{stiffness}}{[K]\left\{q\right\}} = \left\{F(t)\right\}$$

are transformed to the state space canonical form

$$\left\{\dot{x}\right\} = [E]\left\{x\right\} + \left\{G\right\}.$$

where

$$\left\{x\right\} = \begin{Bmatrix} q \\ \dot{q} \end{Bmatrix}$$

$$[E] = \begin{bmatrix} 0 & [I] \\ -[M]^{-1}[k], & -[A]^{-1}[B] \end{bmatrix}$$

and $$\left\{G\right\} = \begin{Bmatrix} 0 \\ [M]^{-1}\left\{F(t)\right\} \end{Bmatrix}$$

The quantity [E] defines the system and $\left\{G\right\}$ the input.

For multi-variable inputs, the equation takes the standard form for linear optimal control theory as

$$\left\{\dot{x}\right\} = [A]\left\{x\right\} + [B]\left\{u\right\}$$

where $\left\{u\right\}$ is the control variable vector, [B] is the shaping matrix, and [A] represents the system characteristics. Introducing a quadratic performance index -- for example, minimum power input or minimum control movement -- allows use of standard methods of optimal control theory for solution.

Subcritical Response

Application of active controls requires an understanding of the subcritical response of the lifting surfaces so that sensor locations can be properly placed and possible instabilities compensated. The control of subcritical response behavior of a vehicle has been determined to be as important as removal of critical speeds from the design or flight envelope [9]. This can be studied with k-E or p-k methods.

Modeling of Aircraft and System Identification

The design of active controls requires a thorough understanding of the vibration modes of the aircraft so that subcritical response and critical flutter response of the vehicle can be predicted and so that sensors for the control system are placed properly. The finite element method is used. Substructuring and component mode synthesis techniques are being increasingly employed to build up whole structure mode behavior from the mode response of individual simple substructures. Although the component mode synthesis technique is not yet fully developed, it is practically the only technique available. The present limitations of the method are therefore reflected in the level of accuracy of predicted vehicle vibration modes.

Another method is to apply system and parameter identification techniques to flight, ground, and wind tunnel tests. A mathematical model is required as a base, and the techniques of system identification are still being developed. Part of the difficulty lies in the dangers inherent in flight flutter testing; considerable work needs to be done in this area.

B-52 Test Program

An important event in the development of controlled configuration vehicles has been the testing of the B52 [10]. An active flutter suppression system designed for that program demonstrates many interesting points. A flutter mode within the speed capabilities of the B52 test vehicle was created by adverse ballasting of wing drop tanks so that flutter occurred at 315 knots with full wing and at 330 knots with half-full wing at an altitude of 21,000 feet. The flutter was symmetric at 2.4 Hz, and the rate of loss of damping was 0.01 g per 10 knots. When an active flutter mode control system was used to augment structural damping, the vehicle could be flown 10 knots faster than its predicted flutter speed.

The flutter mode control system was based on aerodynamic energy methods and utilized active aileron and flaperon control surfaces. The system consisted of two independent control loops. Sensors at the outboard aileron and outboard flaperon detected vertical acceleration of the wing near external fuel tanks. The signal was passed through a shaping filter and used to drive the outboard aileron. The second sensor measured the vertical acceleration of the wing between the engine pods; the signal was passed through the shaping filter and used to drive the outboard flaperon.

Root locus linear analysis techniques were used to synthesize the control system. Twenty seven lowest frequency symmetric and 27 lowest frequency antisymmetric modes were used to synthesize the flutter mode.

CONCLUSION

New concepts in the design of flexible wings for better performance and higher payloads have increased the importance of flutter as a constraint in design. The concepts of oblique wing and active controls were suggested during the last three to five years and are receiving intensive attention. These concepts must be developed further before they can become part of routine design procedures.

Not only do active controls suppress flutter but they can also be used to augment stability, alleviate gust load, reduce fatigue damage, and control ride quality. Control system specialists rather than aerodynamicists or structural engineers are moving to the forefront because the design of flutter suppression systems requires considerable knowledge of electrical and hydraulic systems.

The concept of oblique wings is ingenious and requires further study with regard to its aeroelastic implications. Integrating component mode synthesis with the technique of substructuring and finite element methods also needs further attention. System identification is in its initial stages for two reasons: difficulties in correlating assumed mathematical models with observed test results and the inherent dangers in flight flutter testing. New insight into this area is required.

REFERENCES

1. Murthy, P.N., "Some Recent Trends in Aircraft Flutter Research," Shock Vib. Dig., 7 (12), pp 71-76 (Dec 1975).

2. Jones, R.T., "Reduction of Wave Drag by Antisymmetric Arrangements of Wings and Bodies," AIAA J., 10 (2), pp 171-176 (Feb 1972).

3. Jones, R.T. and Nisket, J.W., "Aeroelastic Stability and Control of an Oblique Wing," Aeronaut. J., pp 365-369 (Aug 1976).

4. Weisshaar, T.A. and Crittendon, J.B., "Flutter of Asymmetric Wings," AIAA J., 14, pp 993-994 (Aug 1976).

5. Crittendon, J.B., Weisshaar, T.A., Johnson, E.H., and Rutkowski, M.J., "Aeroelastic Stability Characteristics of an Oblique Wing Aircraft," J. Aircraft, 15 (7) (July 1978).

6. Perisho, C.H., Triplett, W.E., and Mykytow, W.J., "Design Considerations for an Active Suppression System for Fighter Wing/Store Flutter," Specialist meeting on flutter suppression and structural load alleviation, AGARD-CP-175, pp 1-19 (July 1975).

7. Turner, M.R., "Active Flutter Suppression," Specialist meeting on flutter suppression and structural load alleviation, AGARD-CP-175, pp z-1 to z-14 (July 1975).

8. Nissim, E., "Flutter Suppression Using Active Controls Based on the Concept of Aerodynamic Energy," NASA-TN-D6199 (1971).

9. Garrick, I.E., "Aeroelasticity Frontiers and Beyond," J. Aircraft, 13 (9), pp 641-657 (Sept 1976).

10. Roger, K.L. and Hodges, G.E., "Active Flutter Suppression - A Flight Test Demonstration," J. Aircraft, 12, pp 551-556 (June 1975).

LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains review articles on high temperature damping of dynamic systems, and reduction methods for problems of vibration of orthotropic plates.

Dr. Jones of the Air Force Materials Laboratory, Wright-Patterson AFB, has written an update of his 1976 article. This survey describes four major areas of high-temperature vibration control technology.

Professor Sakata of the Chubu Institute of Technology, Kasugai, Japan, has written a two-part article on reduction methods for problems of vibration of orthotropic plates. Part I describes three exact reduction methods.

HIGH TEMPERATURE DAMPING OF DYNAMIC SYSTEMS

D.I.G. Jones*

Abstract - This survey describes four major areas of high-temperature vibration control technology and progress since late 1976.

- *Measurement and characterization of damping behavior of enamels and glasses and high damping elastomers.*
- *Effects of composition on damping behavior of glasses and enamels.*
- *Practical design and application of damping treatments in industry and service.*
- *Further development of mechanical mechanisms of damping such as slip at interfaces.*

Since the first review of high temperature damping in 1976 [1], little has appeared in the available literature. There has been some progress not reported as yet, but it is nevertheless true that, whenever a vibration control problem arises in a machine or structure in which temperatures are typically above 350°F (177°C), completely satisfactory specific damping materials and treatments are difficult to find. In the temperature range from 400 to 800°F, for example, practically no information is available. Above 800°F, some enamels are known, but complete information of such characteristics as processing, compatibility with substrate materials, and erosion protection is often not available.

Another part of the problem is information transfer. It is becoming increasingly difficult for any individual to keep up with even one area, especially one in which so much work is done in industry where there is no strong incentive to publish. It is possible that person-to-person exchange will become the best way to obtain new information. For this reason, I request that readers of this article who are willing to discuss new developments please contact me, especially with regard to information for the next review! Perhaps this could be one way to achieve technology transfer without adding to the information explosion.

**Air Force Materials Laboratory, Wright-Patterson AFB, Ohio 45433*

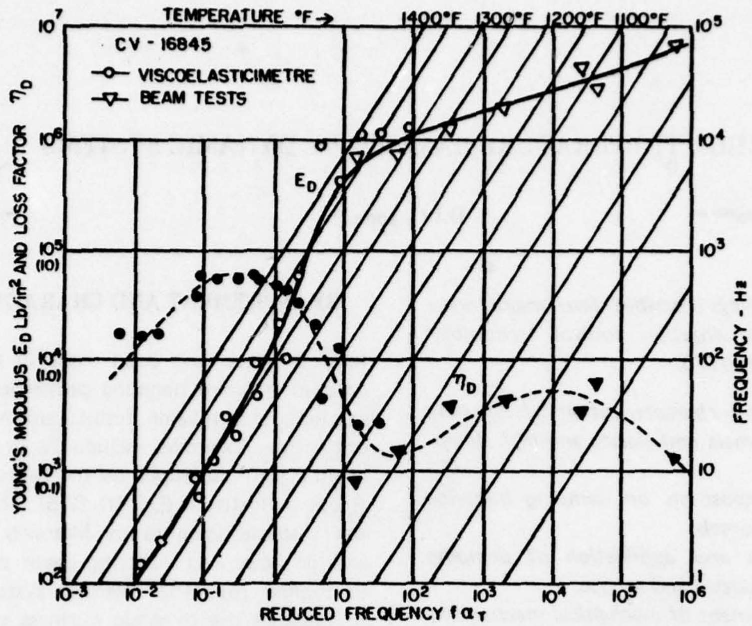
MEASUREMENT AND CHARACTERIZATION

Improvements have been made in the test systems used to measure damping properties of glasses and enamels, and reliable results are now consistently obtainable. Examples include the improved vibrating beam system developed by the University of Dayton Research Institute (UDRI) [2-5], the adaptation of the Viscoelasticimétre by Metravib in France [6], and an improved vibrating beam system by INSA in France [6]. The Metravib system can be used to measure the dynamic stiffness characteristics of relatively soft materials; the vibrating beam techniques are presently applicable to stiffer materials.

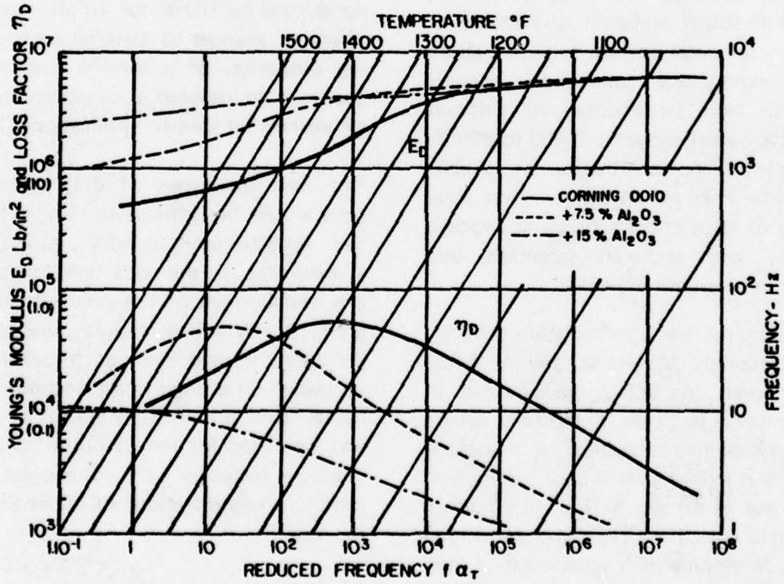
Probably the most significant recent investigation of high-temperature damping behavior of glasses, conducted by UDRI for AFML, had to do with the effect of changes in material composition on damping properties of a specific commercial glass. The goal was to develop a capability to tailor a range of enamels for specific applications [2].

The vast quantities of data generated from the tests would be difficult to handle if it were not for the temperature-frequency equivalence principle. A new step in the data handling process has been the development of the reduced temperature nomogram [7], by which modulus, loss factor, frequency, temperature, and reduced frequency scales can all be placed on a single sheet of modified log-log graph paper. This is immensely useful for detecting trends and was used for the 27-point matrix of glass compositions tested by UDRI. It has also stimulated some useful computerizations of the entire data reduction process [8].

Not many new materials with desirable damping behavior at high temperatures have appeared recently. The enamel matrix [2] is one. Some commercial establishments have continued to develop improved



a. Viscoelasticimétre Technique



b. Vibrating Beam Technique

Figure 1. Test Data on Enamels

materials for industrial and aerospace applications [9-11], but much remains to be done.

Figure 1 shows test data obtained on enamels using the Viscoelasticimetre and vibrating beam techniques [2, 6] and some of the effects of composition changes on typical behavior of glasses. All data are presented in the form of a reduced-temperature nomogram.

TECHNIQUES AND APPLICATIONS

Although industrial and aerospace applications of high-temperature damping materials are increasing and many have been quite successful, unfortunately, with few exceptions [12-14], most are not being discussed in the open literature.

Problems are associated with stabilizing large spacecraft and controlling industrial engine noise, aircraft cabin noise and jet engine vibrations -- only a few of many areas in which damping technology could be useful. But no application will be successful without hard engineering effort.

A recent effort to control vibration-induced cracking on the inlet guide vanes (IGVs) of the TF30 engine illustrates many of the engineering activities involved in a successful and cost effective application [12]. Figure 2 shows the damping treatment: several alternating layers of aluminum foil and appropriate viscoelastic adhesives were bonded with advanced and sophisticated techniques to the IGVs. Figure 3 is a graph of damping level versus temperature; the operational environment is also indicated. This program represented a combined effort of many disciplines and organizations, including the AFML, UDRI, the engine manufacturers (Pratt & Whitney Aircraft), the U.S. Air Logistics Command (OCALC), the 3M Company, and the ASD PRAM office.

Other problems that have been addressed include an inlet extension on a jet engine [13] and an exhaust muffler [14]. Both represent various aspects of high-temperature damping. Successful applications of damping treatments to control diesel engine noise continue to be made [15].

The extremely difficult problem of vibration control in rotating jet engine components remains generally unresolved. Some successful developments of elastomeric bearings [16] show promise for improving balancing technology, but the control of blade vibration remains difficult. Not all blade vibrations induce sufficiently high dynamic stresses to be of concern, but some combinations of high dynamic stresses and high static stresses are difficult to resolve.

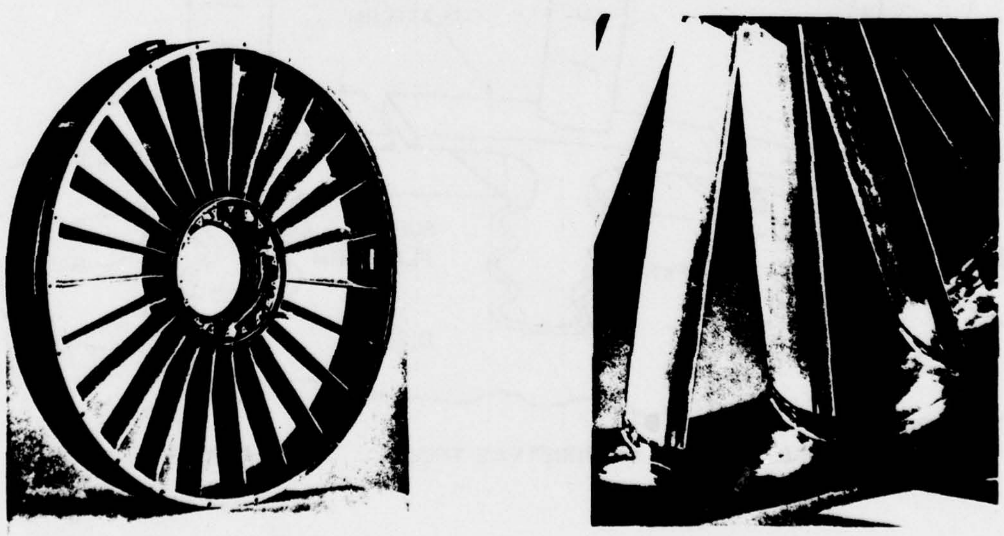


Figure 2. Damping Treatment for Inlet Guide Vanes of a TF30 Engine

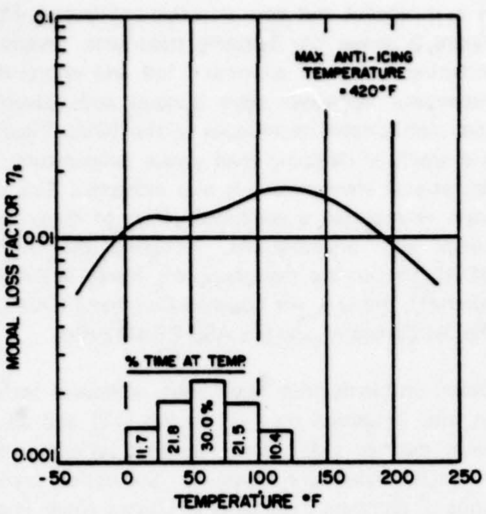


Figure 3. Damping Level vs Temperature of the Damped Inlet Guide Vanes of a TF30 Engine

In such cases, the introduction of damping into the blades is critical but still difficult. The use of a viscoelastic material in the dovetail often introduces damping [17], but long-term stability of enamel coatings in high-temperature blade/disk interfaces -- especially creep -- has not yet been achieved. It is hoped that some progress will be made in the near future. One frequently used current approach is to use mid-span or tip shrouds or loose metal snubbers held against platforms by the centrifugal loads. Analysis of these modifications is difficult, however, and designs can rarely be optimized for high damping from frictional sources. The shrouds and platforms add weight, some of which might be better utilized in alternate blade designs, especially at the blade/disk interface. Figure 4 shows some current designs and possible modifications. Recent analytic results [18-21] have led to some understanding of the nonlinear aspects of the problem and might encourage further developments, especially with regard to detailed and practical design configurations that take full advantage of frictional damping. Spin-pit and engine tests will doubtless be needed.

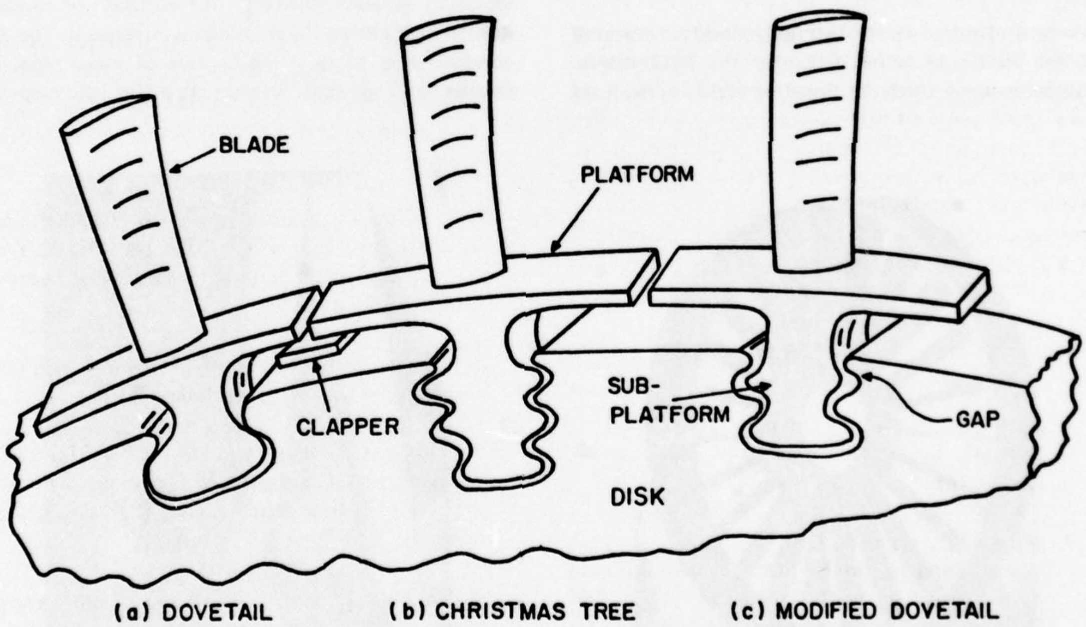


Figure 4. Blade Designs

CONCLUSIONS

Immense difficulties remain to be overcome before high-temperature damping technology reaches the point where specific problems represent routine engineering tasks. It is odd that the literature does not indicate the vast number of vibration problems in industry -- especially the aerospace industry -- that are tolerated, ignored, explained as something else, resolved by managerial or administrative techniques, or just blamed on others. This is true of damping technology in general, but more so for high-temperature damping, and must be very discouraging to those who made efforts to develop the technology in the past. Problems cannot be legislated or jawboned away, however, and it has been our experience at AFML, on countless occasions, that recommendations ignored or considered too difficult or expensive to implement result in two or three years in a return of the problem.

It might be worthwhile to state that much patience will be needed to develop and apply this new and little understood technology, and that all those engineers and scientists who have a professional or personal interest in its continued growth have a real responsibility to bring their own relevant contributions, great or small, to the attention of their peers. The next review of high temperature damping might be such a forum. I challenge my colleagues around the world to do themselves a favor and contact me. Let's make the DIGEST a repository for this now-scattered information. It would benefit all of us to know what is really going on!

REFERENCES

1. Jones, D.I.G., "High Temperature Damping of Dynamic Systems," Shock Vib. Dig., pp 3-16 (Oct 1976).

2. Graves, G., Cannon, C.M., Pantana, C., Goodman, R., and Hilton, S., "On Tailoring a Family of Enamels for High Temperatures Vibration Control," Proc. 15th Ann. Mtg. Soc. Engr. Sci. (SES), Gainesville, FL (Dec 1978).

3. "Behavior Properties and Microstructures of Metallic Materials," UDR-TR-78-38, Parts I and II, Interim Tech. Rept., Contract AF33 615-76-C-5137 (Apr 1978).

4. UDR-TR-78-57, Quart. Prog. Rept. (Apr 1978).

5. UDRI-TR-78-71 (July 1978).

6. Lalanne, M., Trompette, P., Jones, D., derHagopian, J., and Hommeida, A., "Utilization des Materiaux Armortissants pour la Realization d'Elements de Machine Tournante," Compte-rendu de fin d'etudes d'une recherche financee par D.G.R.S.T., Contract 75-7-0968 (Oct 1977).

7. Jones, D.I.G., "A Reduced Temperature Nomogram for Characterization of Damping Materials Behavior," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 48, Pt. 2, pp 13-21 (Sept 1978).

8. Rogers, L.C. and Nashif, A.D., "Computerized Processing and Empirical Representation of Viscoelastic Materials Property Data and Preliminary Constrained Layer Damping Treatment Design," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 48, Pt. 2, pp 23-37 (Sept 1978).

9. Caldwell, D.B., "Selected 3M Materials, Properties, Environmental Resistance and Application," AFFDL-TM-78-FBA, pp 165-182, Proc. Conf. Aerospace Polymeric Viscoelastic Damping Tech., 1980s (1978).

10. O'Keefe, E., "Developments in Damping Technology," AFFDL-TM-78-FBA, pp 185-195, Proc. Conf. Aerospace Polymeric Viscoelastic Damping Tech., 1980s (1978).

11. "Unique Properties Highlight New Elastomer," Rubber World, pp 25-30 (Mar 1978).

12. Rogers, L.C. and Parin, M.L., "A Thoroughly Engineered Application of Damping Technology to Jet Engine Inlet Guide Vanes," AFFDL-TM-78-FBA, pp 277-293 (1978).

13. Drake, M.L. and Sharpe, T.D., "An Example of Additive Damping as a Cost Saving Alternative to Redesign," ASME Paper 77-WA/GT-2 (1977).

14. DeFelice, J.J. and Nashif, A.D., "Damping of an Engine Exhaust Stack," Shock Vib. Bull.,

U.S. Naval Res. Lab., Proc., No. 48, Pt. 2, pp 75-84 (1978).

15. Anatrol Corp., Cincinnati, OH, Private Communication.

16. Tecza, J.A., Darlow, M.S., Jones, S.W., Smalley, A.J., and Cunningham, R.E., "Elastomer Mounted Rotors – An Alternative for Smoother Running Turbomachinery," ASME Gas Turbine Design Conf., San Diego (Mar 1979).

17. Jones, D.I.G. and Knighton, D.L., unpub. expts. on blade root damping, Air Force Matls. Lab.

18. Jones, D.I.G. and Muszyńska, A., "Nonlinear Modelization of Non-Conservative Blade Vibration Response," Proc. 8th Intl. Conf. Non-Linear Oscillations (ICNO 78), Prague, Czechoslovakia (Sept 1978).

19. Jones, D.I.G. and Muszyńska, A., "Vibration of a Compressor Blade with Slip at the Root," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 48, Pt. 2, pp 53-61 (1978).

20. Muszyńska, A. and Jones, D.I.G., "On the Discrete Modelization of Response of Blades with Slip and Hysteretic Damping," to be presented at 5th World Cong., Theory Machines and Mechanisms, Concordia Univ., Montreal, Canada (July 1979).

21. Srinivasan, A.V. (ed.), Structural Dynamics Aspects of Bladed Disk Assemblies, ASME (Dec 1976).

REDUCTION METHODS FOR PROBLEMS OF VIBRATION OF ORTHOTROPIC PLATES

Part I: Exact Methods

T. Sakata*

Abstract - In this two-part article Part I describes three exact reduction methods. Part II describes a generalized reduction method. The reduction method is used to derive an approximate formula for estimating the natural frequency of an orthotropic plate. The natural frequencies of the isotropic plate are used. They are reduced without solving the differential equation governing free vibration of the orthotropic plate.

Applications of composite materials in engineering require information about the behavior of anisotropic materials. The free vibration of an orthotropic plate is an important aspect of such behavior, and many theoretical and experimental studies have been carried out on the vibration of orthotropic plates.

Natural frequencies of a specially orthotropic plate -- defined in this article as a plate whose symmetrical axes coincide with the principal elastic axes of the plate material -- have been studied. Several studies have also recently been reported on a generally orthotropic plate, defined in this article as a plate whose principal elastic axes make arbitrary angles with the sides of the plate [1-11].

It is very difficult to derive a deflection function that satisfies both the differential equation and the boundary conditions. No exact solutions for a specially orthotropic plate or a generally orthotropic plate other than specially orthotropic rectangular plates with two opposite simply supported sides [12, 13] have been reported. The natural frequency of such plates has usually been calculated using various numerical approaches for isotropic plates -- for example, the Rayleigh method, the Rayleigh-Ritz method, the finite difference method, and the finite element method.

Rajappa [12] has proposed an approach called the reduction method, which is based on a reduction equation. This equation is used to estimate the natural frequency of an orthotropic plate. The natural frequency of the isotropic plate is reduced without solving the governing differential equation. Rajappa used the method to estimate the natural frequency of the specially orthotropic rectangular plate shown in Figure 1a. He used the natural frequency of the reduced isotropic rectangular plate shown in Figure 1b. Similar methods have been applied to buckling problems [14, 15] and to a

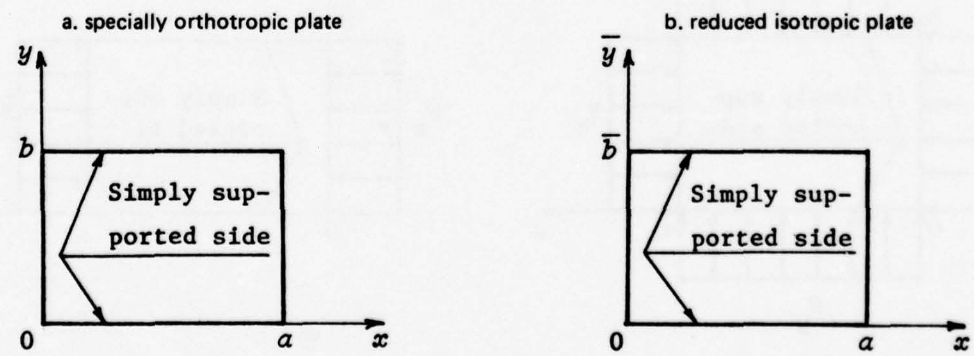


Figure 1. The Rectangular Plates Studied by Rajappa [12]

*Associate Professor, Department of Mechanical Engineering, Chubu Institute of Technology, Kasugai, Nagoya-sub., 487 Japan

bending problem [16]. Wittrick [14] and Shuleshko [15] estimated the buckling forces of the specially orthotropic rectangular plate of Figure 2a from that of the reduced isotropic rectangular plate of Figure 2b. Ashton investigated the correlation between the deflections of the generally orthotropic rectangular plate of Figure 3a and the reduced isotropic skew plate of Figure 3b. The x and y axes are the principal elastic axes of the plate material. A linear transformation is used in these reduction methods. The transformation is on one coordinate axis parallel to the principal elastic axes of the plate material; for example, the x or y axis. The transformation reduces the vibration problem of one plate to another, so that the natural frequency of a specially orthotropic plate can be estimated from that of the reduced isotropic plate.

The reduction methods proposed by Rajappa, Wittrick, Shuleshko, and Ashton are still in an early stage of development as numerical methods, and various conditions on shape, boundary conditions, and flexural rigidities of the plate must be given for each problem. The application of the reduction methods has been limited to the plates shown in Figures 1, 2, and 3. Thus, the reduction methods proposed by Rajappa, Wittrick, and Shuleshko are applicable only to the specially orthotropic rectangular plate with two opposite simply supported sides. The method proposed by Ashton is applicable only to the plate shown in Figure 3 and requires one relation among the flexural rigidities of the plate. This article introduces a reduction method with fewer limitations on flexural rigidities and shape and boundary conditions.

EXACT REDUCTION METHOD FOR A SPECIALLY ORTHOTROPIC CONTINUOUS PLATE

The continuous plate [18, 19] is simply supported along two opposite sides y=0 and y=b, restrained elastically against rotation along the other sides x=0 and x=a, and supported along the intermediate supports $x=x_i$ (i=1,2,...,I−1) perpendicular to the simply supported side y=0 just as the deflection is zero (see Figure 4). Suppose the plate is cut in I pieces along the intermediate supports; consider the i^th piece of the rectangular plate.

According to classical small deflection theory, a free vibration of a thin orthotropic plate subject to bi-axial in-plane forces is given by

$$D_x(\partial^4 W_i/\partial x^4) + 2H(\partial^4 W_i/\partial x^2 \partial y^2) + D_y(\partial^4 W_i/\partial y^4) - N_x(\partial^2 W_i/\partial x^2) - N_y(\partial^2 W_i/\partial y^2) - \rho h_0 \omega^2 W_i = 0 \quad (1)$$

W_i is the deflection of the i^th plate, ρ is the mass density of the plate material, h_0 is the plate thickness,

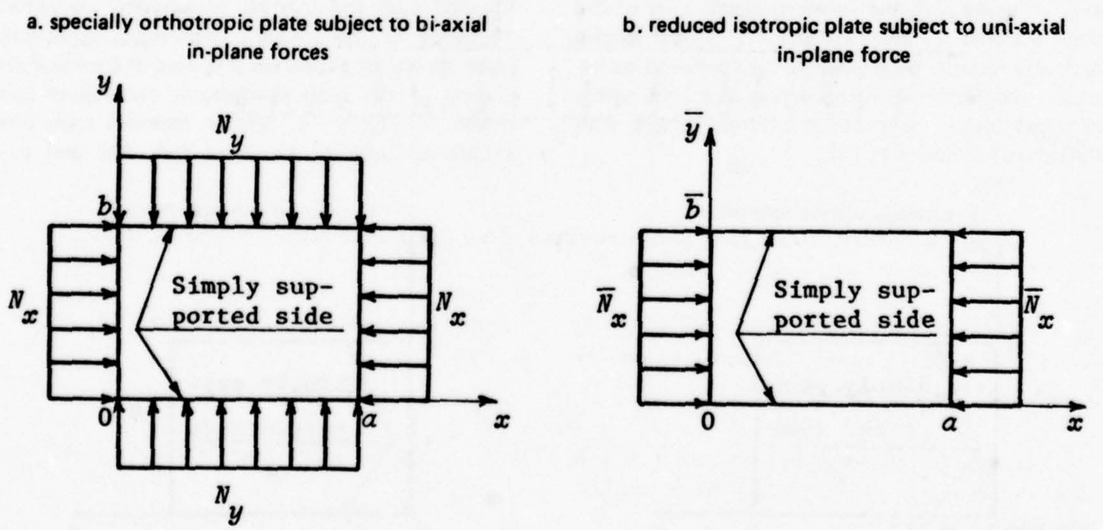


Figure 2. The Rectangular Plates Studied by Wittrick [14] and Shuleshko [15]

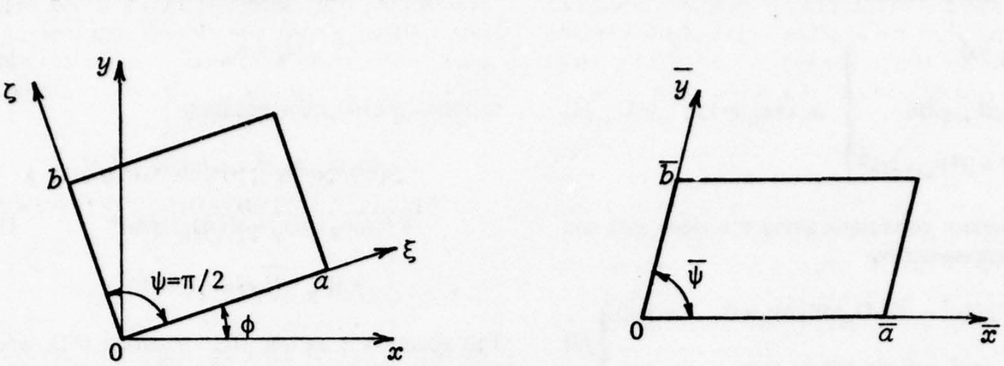


Figure 3. The Plates Studied by Ashton [16]

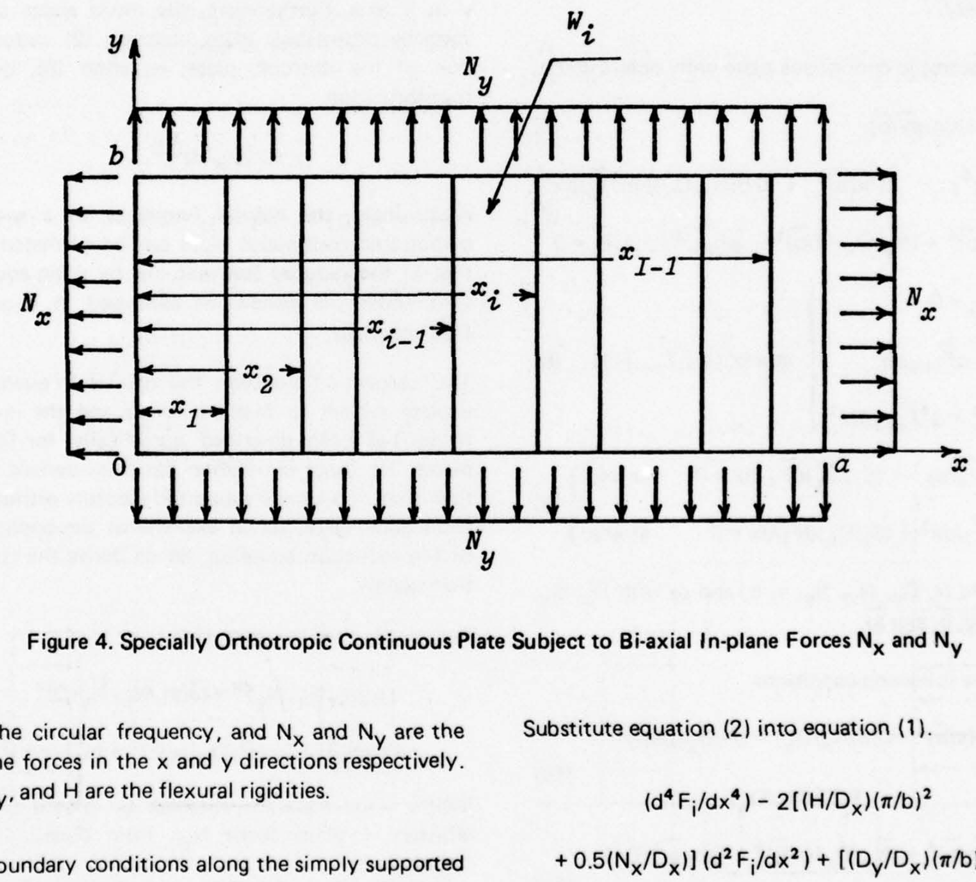


Figure 4. Specially Orthotropic Continuous Plate Subject to Bi-axial In-plane Forces N_x and N_y

ω is the circular frequency, and N_x and N_y are the in-plane forces in the x and y directions respectively. D_x, D_y, and H are the flexural rigidities.

The boundary conditions along the simply supported sides y=0 and y=b are satisfied by using the Levy type solution as the deflection W_i.

$$W_i = F_i(x)\sin(\pi y/b) \qquad (2)$$

Substitute equation (2) into equation (1).

$$(d^4 F_i/dx^4) - 2[(H/D_x)(\pi/b)^2 + 0.5(N_x/D_x)]\,(d^2 F_i/dx^2) + [(D_y/D_x)(\pi/b)^4 + (N_y/D_x)(\pi/b)^2 - (\rho h_0 \omega^2/D_x)]\,F_i = 0 \qquad (3)$$

The conditions along the intermediate supports

$x=x_i$ $(i=1,2,\ldots,I-1)$ are

$$\left.\begin{aligned} F_i &= F_{i+1} = 0 \\ dF_i/dx &= dF_{i+1}/dx \\ d^2F_i/dx^2 &= d^2F_{i+1}/dx^2 \end{aligned}\right\} \text{ at } x=x_i \ (i=1,2,\ldots,I-1) \quad (4)$$

The boundary conditions along the sides x=0 and x=a are represented by

$$\left.\begin{aligned} F_1 &= d^2F_1/dx^2 - (S_1/D_x)dF_1/dx = 0 \quad \text{at } x=0 \\ F_I &= d^2F_I/dx^2 + (S_I/D_x)dF_I/dx = 0 \quad \text{at } x=a \end{aligned}\right\} (5)$$

S_1 and S_I are the stiffnesses per unit length of the elastic restraining medium at the sides x=0 and x=a respectively.

For an isotropic continuous plate with sides a and $\overline{b}$,

$$\overline{W}_i = \overline{F}_i(x)\sin(\pi\overline{y}/\overline{b}) \quad (6)$$

$$\begin{aligned} &(d^4\overline{F}_i/dx^4) - 2[(\pi/\overline{b})^2 + 0.5(\overline{N}_x/D_x)](d^2\overline{F}_i/dx^2) \\ &\quad + [(\pi/\overline{b})^4 + (\overline{N}_y/D_x)(\pi/\overline{b})^2 - (\rho h_0\overline{\omega}^2/D_x)]\overline{F}_i = 0 \end{aligned} \quad (7)$$

$$\left.\begin{aligned} \overline{F}_i &= \overline{F}_{i+1} = 0 \\ d\overline{F}_i/dx &= d\overline{F}_{i+1}/dx \\ d^2\overline{F}_i/dx^2 &= d^2\overline{F}_{i+1}/dx^2 \end{aligned}\right\} \text{ at } x=x_i(i=1,2,\ldots,I-1) \quad (8)$$

$$\left.\begin{aligned} \overline{F}_1 &= d^2\overline{F}_1/dx^2 - (S_1/D_x)d\overline{F}_1/dx = 0 \quad \text{at } x=0 \\ \overline{F}_I &= d^2\overline{F}_I/dx^2 + (S_I/D_x)d\overline{F}_I/dx = 0 \quad \text{at } x=a \end{aligned}\right\} (9)$$

Substitute H, D_y, N_x, N_y, y, b, and ω with D_x, D_x, $\overline{N}_x$, $\overline{N}_y$, $\overline{y}$, $\overline{b}$, and $\overline{\omega}$.

Under the following conditions

$$\begin{aligned} (\pi/\overline{b})^2 + 0.5(\overline{N}_x/D_x) &= (H/D_x)(\pi/b)^2 \\ &\quad + 0.5(N_x/D_x) \end{aligned} \quad (10)$$

$$\begin{aligned} &(\pi/\overline{b})^4 + (\overline{N}_y/D_x)(\pi/\overline{b})^2 - (\rho h_0\overline{\omega}^2/D_x) \\ &= (D_y/D_x)(\pi/b)^4 + (N_y/D_x)(\pi/b)^2 - (\rho h_0\omega^2/D_x) \end{aligned} \quad (11)$$

equations (3) to (5) reduce to equations (7) to (9).

Assume $\quad \overline{b} = b(D_x/H)^{0.5} \quad (12)$

$$\overline{N}_x = N_x, \quad (13)$$

to obtain the reduction equation

$$\begin{aligned} \omega(m,N_x,N_y)^2 &= \overline{\omega}(m,\overline{N}_x,\overline{N}_y)^2 \\ &+ (1/\rho h_0)[(D_y - H^2/D_x)(\pi/b)^4 \\ &+ (N_y - \overline{N}_y H/D_x)](\pi/b)^2 \end{aligned} \quad (14)$$

This equation is derived from equation (11), where $\omega(m, N_x, N_y)$ and $\overline{\omega}(m, \overline{N}_x, \overline{N}_y)$ are the natural frequencies of the specially orthotropic and isotropic continuous plates, respectively. The integer m represents the number of the nodal line parallel to the y or $\overline{y}$ axis. Furthermore, the mode shape of the specially orthotropic plate, equation (2), reduces to that of the isotropic plate, equation (6), by the transformation

$$\overline{y} = y(D_x/H)^{0.5} \quad (15)$$

Accordingly, the natural frequency of a specially orthotropic continuous plate can be estimated from that of the reduced isotropic one by using equation (14) under the conditions expressed in equations (12) and (13).

The correlation between the natural frequency of a plate subject to in-plane forces and the in-plane forces has been described numerically for various plates. No exact correlation has been derived other than that of a simply supported specially orthotropic rectangular plate. As an example of the application of the reduction equation, let us derive the correlation exactly.

Assume $\overline{N}_y$=0 in equation (14)

$$\begin{aligned} \omega(m,N_x,N_y)^2 &= \overline{\omega}(m,\overline{N}_x,\overline{N}_y=0)^2 \\ &+ (1/\rho h_0)[(D_y - H^2/D_x)(\pi/b)^2 + N_y](\pi/b)^2 \end{aligned} \quad (16)$$

Subtract the equation obtained by substituting an arbitrary in-plane force N_{ys} from equation (16) to obtain

$$\begin{aligned} \omega(m,N_x,N_y)^2 - \omega(m,N_x,N_{ys})^2 \\ = (1/\rho h_0)(N_y - N_{ys})(\pi/b)^2 \end{aligned} \quad (17)$$

Because $\omega(m, N_x, N_y) = 0$ for $N_y = N_y(m, N_x)$, in which $N_y(m, N_x)$ denotes the buckling force of the specially orthotropic continuous plate subject to in-plane force N_x,

$$\omega(m, N_x, N_{ys})^2 = (-1/\rho h_0)[N_y(m, N_x) - N_{ys}](\pi/b)^2 \tag{18}$$

From equations (17) and (18)

$$\frac{\omega(m,N_x,N_y)}{\omega(m,N_x,N_{ys})} = \left[1 - \frac{N_y - N_{ys}}{N_y(m,N_x) - N_{ys}}\right]^{0.5} \tag{19}$$

EXACT REDUCTION METHOD FOR A GENERALLY ORTHOTROPIC PLATE WITH ARBITRARY SHAPE

Let the principal elastic axes of the plate material be the coordinate axes x and y, and consider a harmonic vibration of a thin orthotropic plate with an arbitrary curvilinear boundary $\Gamma(x, y) = 0$, as shown in Figure 5 [20]. According to classical small deflection theory, a free vibration of an orthotropic plate with uniform thickness is governed by the partial differential equation

$$D_x(\partial^4 W/\partial x^4) + 2H(\partial^4 W/\partial x^2 \partial y^2) + D_y(\partial^4 W/\partial y^4) - \rho h_0 \omega^2 W = 0 \tag{20}$$

W is the deflection; ρ is the mass density of the plate material; h_0 is the plate thickness; ω is the circular frequency; and D_x, H, D_y, and D_1 are the flexural rigidities.

Under the transformation

$$y^* = \lambda y \tag{21}$$

where λ is a constant, equation (20) reduces to

$$D_x(\partial^4 W/\partial x^4) + 2H^*(\partial^4 W/\partial x^2 \partial y^{*2}) + D_y^*(\partial^4 W/\partial y^{*4}) - \rho h_0 \omega^2 W = 0 \tag{22}$$

where

$$H^* = \lambda^2 H \tag{23}$$

$$D_y^* = \lambda^4 D_y \tag{24}$$

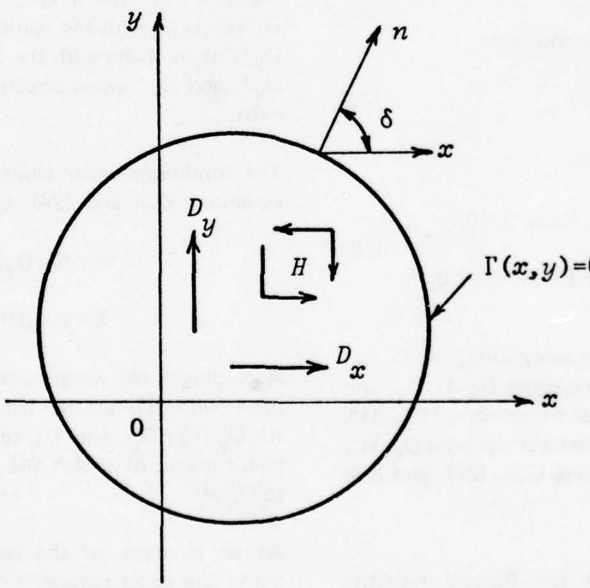


Figure 5. An Orthotropic Plate with an Arbitrary Curvilinear Boundary

Equation (22) is the governing equation for an orthotropic plate with the flexural rigidities D_x, H^*, D_y^*, and D_1^*, although D_1^* is not as yet defined. The boundary $\Gamma(x, y) = 0$ also reduces to $\Gamma(x, y^*/\lambda) = 0$.

For a simply supported plate with the flexural rigidities D_x, H, D_y, and D_1, the boundary condition is represented by

$$W(x, y) = M_n(x, y) = 0 \quad \text{along the boundary } \Gamma(x, y) = 0, \tag{25}$$

where M_n denotes the bending moment in the normal direction of the boundary. Under the transformation shown in equation (21), equation (25) reduces to

$$W(x, y^*/\lambda) = M_n(x, y^*/\lambda) = 0 \quad \text{along the boundary } \Gamma(x, y^*/\lambda) = 0. \tag{26}$$

Denote the bending moment in the normal direction of the boundary of the reduced plate by $M_n^*(x, y^*)$.

$$M_n^*(x, y^*) = 0 \quad \text{along the boundary } \Gamma(x, y^*/\lambda) = 0 \tag{27}$$

from equation (26) under the condition

$$D_1^* = \lambda^2 D_1 \tag{28}$$

From equations (26) and (27)

$$W(x, y^*/\lambda) = M_n^*(x, y^*) = 0 \quad \text{along the boundary } \Gamma(x, y^*/\lambda) = 0 \tag{29}$$

Accordingly, the natural frequency $\omega(D_x, H, D_y)$ of the plate with the flexural rigidities D_x, H, D_y, and D_1 coincides with the natural frequency $\omega^*(D_x, H^*, D_y^*)$ of the plate with the flexural rigidities D_x, H^*, D_y^*, and D_1^* when equations (23), (24), and (28) exist between both plates.

For a clamped plate with the flexural rigidities D_x, H, D_y, and D_1, the boundary condition is represented by

$$W(x, y) = \theta_n(x, y) = 0 \quad \text{along the boundary } \Gamma(x, y) = 0 \tag{30}$$

where θ_n denotes the slope in the normal direction of the boundary. Under the transformation, equation (21), equation (30) reduces to

$$W(x, y^*/\lambda) = \theta_n(x, y^*/\lambda) = 0 \quad \text{along the boundary } \Gamma(x, y^*/\lambda) = 0 \tag{31}$$

Denoting the slope in the normal direction of the boundary of the reduced plate by $\theta_n^*(x, y^*)$ does not always yield

$$W(x, y^*/\lambda) = \theta_n^*(x, y^*) = 0 \quad \text{along the boundary } \Gamma(x, y^*/\lambda) = 0 \tag{32}$$

from equation (31). But equation (32) is valid when the deflection W satisfies

$$\partial W/\partial x = \partial W/\partial y = 0 \quad \text{along the boundary } \Gamma(x, y) = 0. \tag{33}$$

According, the natural frequency $\omega(D_x, H, D_y)$ of the plate with the flexural rigidities D_x, H, D_y, and D_1 coincides with the natural frequency $\omega^*(D_x, H^*, D_y^*)$ of the plate with the flexural rigidities D_x, H^*, D_y^*, and D_1^* when equations (23), (24), and (33) exist.

The conditions under which H^* and D_y^*, given by equations (23) and (24), become equal to D_x, are

$$H = (D_x D_y)^{0.5} \tag{34}$$

$$\lambda = (D_x/H)^{0.5} \tag{35}$$

Accordingly, the vibrating problem of an orthotropic plate with the special flexural rigidities D_x, $H = (D_x D_y)^{0.5}$, D_y, and D_1 reduces to that of an isotropic plate, of which the Poisson ratio υ is equal to D_1/H.

As an example of the reduction method, let us derive the exact natural frequency $\omega(D_x, H, D_y)$ of a generally orthotropic skew plate with the special flexural rigidities D_x, $H = (D_x D_y)^{0.5}$, and D_y (see

a. a simply supported generally orthotropic skew plate

b. a simply supported isotropic rectangular plate reduced from the skew plate

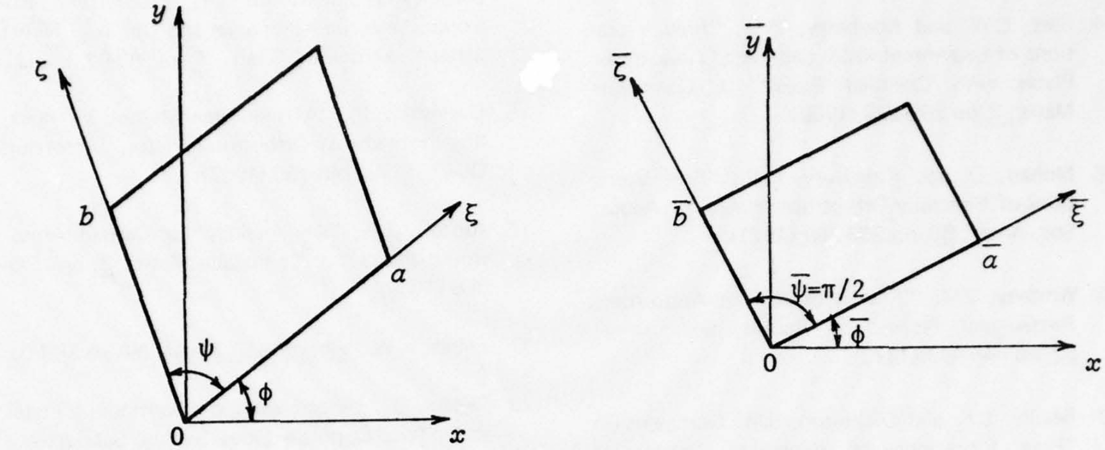


Figure 6. Plates

Figure 6b). The transformation is represented by

$$\bar{y} = y(D_x/H)^{0.5} \tag{36}$$

Therefore,

$$\left.\begin{aligned} \tan\phi &= (H/D_x)^{0.5}\tan\bar{\phi} \\ \tan(\phi+\psi) &= (H/D_x)^{0.5}\tan(\bar{\phi}+\bar{\psi}). \end{aligned}\right\} \tag{37}$$

Because $\bar{\psi} = \pi/2$ the skew angle ψ is given by

$$\psi = \tan^{-1} \left| [1 + (D_x/H)\tan^2\phi]/[\ 1 - (D_x/H)\ \tan\phi] \right| \tag{38}$$

The side ratios $\bar{a}/\bar{b}$ and $a/\bar{a}$ are given by

$$\bar{a}/\bar{b} = (a/b)f_1 \tag{39}$$

$$a/\bar{a} = (f_2)^{0.5} \tag{40}$$

where

$$f_1 = (H/D_x)^{0.5}/(\cos\psi\tan\phi + \sin\psi) \tag{41}$$

$$f_2 = 1/[\cos^2\phi + (D_x/H)\sin^2\phi] \tag{42}$$

The natural frequency $\bar{\omega}(D_x)$ of a simply supported isotropic rectangular plate is exactly given by

$$\bar{\omega}(D_x) = [(i+1)^2 + \left\{ (\bar{a}/\bar{b})(j+1) \right\}^2]\,(\pi^4 D_x/\rho h_0 \bar{a}^4)^{0.5} \tag{43}$$

D_x is the flexural rigidity, and the non-negative integers i and j denote the numbers of the nodal lines to $\bar{\xi}$ and $\bar{\zeta}$ axes, respectively. The natural frequency $\omega(D_x,\ H,\ D_y)$ of the simply supported generally orthotropic skew plate of Figure 6a is given by

$$\begin{aligned} &\omega(D_x, H, D_y) \\ &= [(i+1)^2 + \left\{ (a/b)f_1(j+1) \right\}^2]\,f_2\,(\pi^4 D_x/\rho h_0 a^4)^{0.5} \end{aligned} \tag{44}$$

REFERENCES

1. Ashton, J.E., "Natural Modes of Free-free Anisotropic Plates," Shock Vib. Bull., U.S. Naval Res. Labs., Proc., 39, pp 93-100 (1969).

2. Ashton, J.E. and Waddoups, M.F., "Analysis of Anisotropic Plates," J. Composite Matls., 3, pp 140-165 (1969).

3. Ashton, J.E. and Anderson, J.D., "Natural Modes of Vibration of Boron-Epoxy Plates," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., 39, pp 81-91 (1969).

4. Bert, C.W. and Mayberry, B.L., "Free Vibrations of Unsymmetrically Laminated Anisotropic Plates with Clamped Edges," J. Composite Matls., 3, pp 282-293 (1969).

5. Mohan, D. and Kingsbury, H.B., "Free Vibrations of Generally Orthotropic Plates," J. Acoust Soc. Amer., 50, pp 266-269 (1971).

6. Whitney, J.M., "Free Vibration of Anisotropic Rectangular Plates," J. Acoust. Soc. Amer., 52, pp 448-449 (1972).

7. Bassily, S.F. and Dickinson, S.M., Comment on "Free Vibrations of Generally Orthotropic Plates," J. Acoust. Soc. Amer., 52, pp 1050-1053 (1972).

8. Maurizi, M.J. and Laura, P.A., "Vibration Analysis of Clamped, Rectangular Plates of Generalized Orthotropy," J. Sound Vib., 26, pp 299-305 (1973).

9. Nair, P.S. and Durvasula, S., "Vibration of Generally Orthotropic Skew Plates," J. Acoust. Soc. Amer., 55, pp 998-1002 (1974).

10. Srinivasan, R.S. and Ramachandran, S.V., "Vibration of Generally Orthotropic Skew Plates," J. Acoust. Soc. Amer., 57, pp 1113-1118 (1975).

11. Nair, P.S., Comments on "Vibration of Generally Orthotropic Skew Plates," J. Acoust. Soc. Amer., 59, pp 1502-1503 (1976).

12. Rajappa, N.R., "On the Exact Solutions of Vibration Problems of Rectangular Orthotropic Plates," Z. Angewandte Math. Phys., 15, pp 201-205 (1964).

13. Vijayakumar, K., "Natural Frequencies of Rectangular Orthotropic Plates with a Pair of Parallel Edges Simply Supported," J. Sound Vib., 35, pp 379-394 (1974).

14. Wittrick, W.H., "Correlation between Some Stability Problems for Orthotropic and isotropic Plates under Bi-axial and Uni-axial Direct Stress," Aeronaut. Quart., 4, pp 83-92 (1952).

15. Shuleshko, P., "A Reduction Method for Buckling Problems of Orthotropic Plates," Aeronaut. Quart., 8, pp 145-156 (1957).

16. Ashton, J.E., "An Analogy for Certain Anisotropic Plates," J. Composite Matls., 3, pp 355-358 (1969).

17. Leissa, A.W., Vibration of Plates, NASA SP-160.

18. Sakata, T., "Eigenvalues of Continuous Plates with Two Opposite Sides Simply Supported," J. Sound Vib., 47, pp 577-583 (1976).

19. Sakata, T., "A Reduction Method for Vibrating and Buckling Problems of Orthotropic Continuous Plates," J. Sound Vib., 49, pp 45-52 (1976).

20. Sakata, T., "A Reduction Method for Problems of Vibration of Orthotropic Plates," J. Sound Vib., 48, pp 405-412 (1976).

21. Sakata, T., "Generalized Procedure of Reduction Method for Vibrating Problems of Orthotropic Plates," J. Franklin Inst., 303, pp 415-424 (1977).

22. Hearmon, R.F.S., "The Frequency of Flexural Vibration of Rectangular Orthotropic Plates with Clamped and Supported Edges," J. Appl. Mech., Trans. ASME, 26, pp 537-540 (1959).

23. Bauer, L. and Reiss, E.L., "Flexural Vibrations of Clamped Orthotropic Plates," J. Acoust. Soc. Amer., 53, pp 1360-1364 (1973).

24. Sato, K., "Free Flexural Vibrations of an Elliptical Plate with Elastically Restrained Edge," Trans. JSME, 41, pp 1996-2001 (1975).

BOOK REVIEWS

INTRODUCTION TO STOCHASTIC PROCESSES

E. Cinlar
Prentice-Hall, 1975

This book is intended as an introductory textbook on stochastic processes. Discrete-valued processes constitute the main topics; emphasis is placed upon Bernoulli processes, Markov processes, and renewal theory.

In comparison with other books in this area, this book is a useful addition for readers who are mainly interested in discrete-valued processes. It has an extensive coverage of Markov chains, queuing, and renewal processes. The author has made an effort to stress the sample-path approach, but is only partially successful from the point of view of motivation and following-through in applications.

A difficulty is the awkward notation used, such as $\phi(a)$ for the probability distribution function, $\pi(a)$ for the probability mass function, and the apparent absence of a notation for the probability density function.

T.T. Soong
Professor of Civil Engineering
State University of New York at Buffalo
Buffalo, New York 14214

THE PHYSICS OF VIBRATIONS AND WAVES

2nd Edition

H.J. Pain
John Wiley and Sons, Ltd., 1976

The author points out in the introduction that the book is derived from lecture notes for a course in a physics degree program at the Imperial College. The book is thus probably best suited for undergraduate courses in the physics of waves as applied to such fields as mechanics, optics, and electromagnetics, as opposed to engineering courses in, for example, wave propagation in solids.

Each of the 12 chapters contains problems and a short synopsis of significant material discussed in the text. As the text is developed, problems at the end of the chapter are referred to if the information will aid in solving the problems. If a particular subsection in a chapter is not important to later developments and can be omitted, it is so noted. In these matters, the book seems particularly suited to use as an undergraduate text. However, the book covers a wide variety of topics in wave propagation in relatively few pages, and thus many derivations are somewhat incomplete. If the book is used as a course text, this minor limitation can be overcome during lectures.

The first three chapters cover material that would be suitable for an undergraduate introduction to vibrations for non-structures-oriented students. It includes single-degree-of-freedom systems with and without damping, as well as forced oscillations and a brief introduction to the normal mode method.

The next four chapters are devoted to transverse and longitudinal waves, waves on transmission lines, and electromagnetic wave theory. The one-dimensional wave equation is developed for transverse and longitudinal waves and applied to mechanical, atomic, and acoustic phenomena in Chapters 4 and 5. Concepts of impedance and the use of impedance for calculating and minimizing losses due to reflections are included. In Chapter 6, electrical power transmission is discussed; the concepts of resistive losses leading to the diffusion equation are introduced. Chapter 7 develops Maxwells laws for electromagnetic wave propagation.

In Chapter 10, the phenomena of interference and diffraction of waves are developed using Fourier methods discussed in Chapter 9. Diffraction from narrow slits, rectangular and circular apertures, and transmission diffraction gratings are discussed.

Nonlinear oscillations are discussed in Chapter 11 but not in sufficient detail to be applied to nonlinear effects in wave propagation in mechanical systems. The last chapter deals with quantum physics and contains a brief historical review of developments in the field.

The book is probably best suited for use in an undergraduate course in physics. However, for engineers whose interests span several disciplines (electro-optical-mechanical) this book would provide a good introduction to the physics of waves -- information fundamental to the understanding of phenomena across the electromagnetic spectrum.

W.R. Case
Instrument Division
NASA
Goddard Space Flight Center
Greenbelt, Maryland 20771

COMPOSITES IN PRESSURE VESSELS AND PIPING

S.V. Kulkerni and C.H. Zweben, Editors
ASME, New York, 1977

This book contains the papers presented at technical sessions on composites in pressure vessels and piping held during the Energy Technology Conference and Exhibition from September 19-23, 1977 in Houston. The sessions were sponsored by the Pressure Vessels and Piping Division of the American Society of Mechanical Engineers.

Conlisk and Fowler present the topic of failures of glass fiber-reinforced tanks and vessels resulting from the misapplication of metal vessel design rules and methods to fiber-reinforced plastics (FVP). A new method of testing FVP, using acoustic emissions, is also discussed.

Lark reviews recent advances in filament-wound composite pressure vessel technology, including design concepts, fabrication procedures, applications, and performance of vessels subjected to single cycle burst and cyclic fatigue loading. He emphasizes thin-lined pressure vessels.

During the winding/curing operation of composite vessels with load-sharing liners, residual compressive stresses in the liner and tensile stresses in the overwrap are induced. Upon subsequent application of internal pressure ("sizing" pressure), the linear material deforms plastically. Release of the "sizing" pressure produces a permanent deformation in the liner, inducing a predominantly compressive stress. Consequently, during fatigue cycling, the liner behaves elastically in the tension-compression mode; the overwrap also behaves elastically in the tension-tension mode. The relationship between liner plastic deformation characteristics and the failure mode is established by Jones. Elastic-plastic finite element analysis is used to investigate fatigue and stress rupture behavior of operating vessels. The S-Glass/aluminum oxygen cylinder used by the U.S. Bicentennial Everest expedition is discussed.

When the composite overwrap in metal-lined vessels is thick, the state of stress and strain is nonlinear through the thickness. This gradient, which is more pronounced for materials with greater anisotropy, causes a loss in structural efficiency. As a remedy, Gerstle and Moss suggest a more efficient design using two discrete composite layers (akin to the "hybrid" laminate concept) selected to increase the load carried by the outer layer. This increased load is accomplished by overwrapping a strong, compliant composite (such as "Kevlar" 49 aramid) with a stiffer material (such as "Thornel" 300).

A comprehensive discussion of aerospace and commercial applications of composite pressure vessels is given by Morris, Patterson, Landes, and Gordon. An example of a full-scale hardware demonstration program to establish the technological readiness and suitability of composite vessels for future flight vehicles is discussed. Both "Kevlar" 49/stainless steel and "Kevlar" 49/aluminum alloy vessels are investigated. Commercial applications of pressure vessels are generally governed by such standards or codes as those of ASME, ASTM, NBS, or DOT. A review of DOT authorizations and the NASA technology utilization program are discussed for an S-glass/aluminum fireman's compressed air breathing system pressure vessel and a "Kevlar" 49 aramid/aluminum commercial aircraft compressed gas pressure vessel for the long-range Boeing 747 SP aircraft.

A program for assessing the utility of high-pressure gas containers (titanium and Inconel liners over-wrapped with "Kevlar" 49 fibers) for space shuttle orbiter propulsion and environmental control subsystems is described by Ecord. Vessel characteristics, design features, and test results are presented along with brief descriptions of processes and nondestructive evaluation techniques.

Acoustic emission tests for predicting burst pressure of a filament wound "Kevlar" 49/aluminum vessel are reported by Hamstad and Patterson. The study focuses on three specific areas: development of an experimental technique and instrumentation to measure the energy given off by acoustic emission transducers per acoustic emission burst; design of a test fixture in which to mount the composite vessel; and consideration of the number, location, and sensitivity of acoustic emission transducers used for proof testing.

Finally, manufacturing methods for PVP are explored by Goldsworthy. The topics discussed are continuous small diameter pipe, centrifugal casting for large diameter pipe and tanks, and on-site tank construction. The various ways in which the unique properties of composite pipe might change construction, handling, and usage techniques are also noted.

T.J. Chung
Professor of Mechanical Engineering
University of Alabama in Huntsville
P.O. Box 1247
Huntsville, Alabama 35807

SHORT COURSES

MAY

THE FIFTH ANNUAL RELIABILITY TESTING INSTITUTE

Dates: May 14-18, 1979
Place: University of Arizona
Objective: To provide reliability engineers, product assurance engineers and managers and all other engineers and teachers with a working knowledge of analyzing component, equipment, and system performance and failure data to determine the distributions of their times to failure, failure rates, and reliabilities, small sample size, short duration, low cost tests, and methods of analyzing their results; Bayesian testing; suspended items testing; sequential testing; and others.

Contact: Special Professional Education, College of Engineering, University of Arizona, Old Engineering Bldg., Tucson, AZ 85721 - (602) 626-3054.

(ITD) IBRAHIM TIME DOMAIN MODAL VIBRATION TESTING TECHNIQUE

Dates: May 17-18, 1979
Place: Virginia Beach, Virginia
Objective: The ITD method is applicable to almost all kinds of structures. The workshop is designed such that attendees, after the workshop, will be able to apply the technique to their specific application. Material for the workshop will include computer programs for the time domain identification and the random decrement techniques.

Contact: W. McMahon, Director, Industrial Programs, School of Continuing Education, Old Dominion University, Norfolk, VA 23508 - (804) 489-6467.

STRUCTURED PROGRAMMING AND SOFTWARE ENGINEERING

Dates: May 21-25, 1979
Place: The George Washington University
Objective: This course provides up-to-date technical knowledge of logical expression, analysis, and invention for performing and managing software architecture, design, and production. Presentations will cover principles and applications in structures programming and software engineering, including stepwise refinement, program correctness, and top-down system development.

Contact: Continuing Engineering Education Program, George Washington University, Washington, D.C. 20052 - (202) 676-6106 or toll free (800) 424-9773.

JUNE

NON-LINEAR PARTIAL DIFFERENTIAL EQUATIONS IN ENGINEERING AND APPLIED SCIENCES

Dates: June 4-8, 1979
Place: University of Rhode Island
Objective: The conference will feature overview lectures and talks on recent developments in non-linear partial differential equations with emphasis in the areas of solitons, bifurcation, solid and fluid dynamics, non-linear waves, and non-linear diffusion.

Contact: Emilio Roxin or John Papadakis, Dept. of Mathematics, University of Rhode Island, Kingston, Rhode Island 02881 - (401) 792-2709.

ROTOR DYNAMICS

Dates: June 5-8, 1979
Place: Charlottesville, Virginia
Objective: Topics to be covered are fundamentals of rotor dynamics, optimization of fluid film bearings for stability and unbalance response, squeeze film damper design for compressors and turbines, field techniques of balancing, instrumentation, experimental rotor behavior and case histories.

Contact: Dr. Edgar J. Gunter, RODYN Vibration Short Course, P.O. Box 3301, University of Virginia Station, Charlottesville, VA 22903 - (804) 924-3982.

FIBROUS COMPOSITE STRUCTURES

Dates: June 5-8, 1979

Place: The George Washington University

Objective: The course will treat the mechanics of fibrous composite parts and structures, and their structural analysis, design, testing, and fabrication. Topics to be covered include micro- and macro-mechanics of composites, strength theories for composites, analysis, design, and manufacturing techniques for composite structures.

Contact: Continuing Engineering Education Program, George Washington University, Washington, D.C. 20052 - (202) 676-6106 or toll free (800) 424-9773.

FINITE ELEMENTS, A UNIFIED TREATMENT OF STRUCTURAL SYSTEMS - STATICS, DYNAMICS AND STABILITY

Dates: June 11-22, 1979

Place: UCLA

Objective: The presentation constitutes a unified finite element treatment of structural systems that brings together static, dynamic and stability analysis, both in terms of problem formulation and solution. Techniques are explored that are most suitable for solution by a digital computer. Modern computer programs are also discussed.

Contact: Continuing Education in Engineering and Mathematics, P.O. Box 24902, UCLA Extension, Los Angeles, CA 90024 - (213) 825-3344/825-1295.

ACOUSTIC EMISSION STRUCTURAL MONITORING TECHNOLOGY

Dates: June 18-19, 1979

Place: Los Angeles, California

Objective: A theory and practice course covering each of the various facets of acoustic emission structural monitoring technology; basic phenomena, state-of-the-art applications, field testing experience, applicable codes and standards and instrumentation design and calibration. This course also includes "hands-on" operation of minicomputer and microcomputer acoustic emission systems. This course is designed for potential users of acoustic emission structural monitoring systems.

Contact: C.A. Parker, Nuclear Training Center, Atomics International, P.O. Box 309, Canoga Park, CA 91304 - (213) 341-1000, Ext. 2811.

INSTRUMENTATION FOR MECHANICAL ANALYSIS

Dates: June 25-29, 1979

Place: University of Michigan

Objective: Emphasis is on the use of instruments by non-electrical engineers to analyze systems. Attendees will use a wide range of transducers and associated instrumentation. Lectures are devoted to theory and hands-on laboratory work and demonstrations.

Contact: Engineering Summer Conferences, 200 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109.

DYNAMICS OF STRUCTURAL AND MECHANICAL SYSTEMS

Dates: June 25-29, 1979

Place: UCLA

Objective: The course presents the area of structural dynamics at an intermediate to advanced level. The course emphasizes discrete methods, numerical methods and structural modeling for computer-oriented solution of various structural dynamic problems. Some recent developments in the structural dynamic analysis of parametrically excited systems, rotating systems and systems in which fluid-structure dynamic interactions occur are also considered.

Contact: Continuing Education in Engineering and Mathematics, P.O. Box 24902, UCLA Extension, Los Angeles, CA 90024 - (213) 825-3344/825-1295.

MACHINERY VIBRATIONS SEMINAR

Dates: June 26-28, 1979 & October 23-25, 1979

Place: Mechanical Technology Inc., Latham, NY

Objective: To cover the basic aspects of rotor-bearing system dynamics. The course will provide a fundamental understanding of rotating machinery vibrations; an awareness of available tools and techniques for the analysis and diagnosis of rotor vibration problems; and an appreciation of how these techniques are applied to correct vibration problems. Technical personnel who will benefit most from this course are those concerned with the rotor dynamics evaluation of motors, pumps, turbines, compressors, gearing, shafting, couplings, and similar mechanical equipment. The attendee should possess an engineering degree with some understanding of mechanics of materials and vibration theory. Appropriate job functions include machinery designers; and plant, manufacturing, or service engineers.

Contact: Mr. Paul Babson, MTI, 968 Albany-Shaker Rd., Latham, NY 12110 - (518) 785-2371.

JULY

INDUSTRIAL PRODUCT NOISE CONTROL

Dates: July 9-13, 1979
Place: Union College, Schenectady, New York
Objective: This course is designed for engineers, designers, environmental health specialists and managers concerned with noise and vibration control. A background in theory, measurement and economics of noise reduction is provided. The basic nature of sound and noise control will be discussed, as well as noise criteria, airborne sound distributions, vibration control and noise signature analysis.

Contact: Office of Graduate Studies and Continuing Education, Wells House, 1 Union Ave., Union College, Schenectady, NY 12308 - (518) 370-6288.

FRACTURE MECHANICS I

Dates: July 16-20, 1979
Place: Union College, Schenectady, New York
Objective: This course is designed to illustrate the use of fracture mechanics as a practical tool in engineering design. The institute will benefit those concerned with the application of fracture mechanics to the prevention of fracture in pressure vessels for power generation, for example, or welded structural frameworks for buildings and bridges.

Contact: Office of Graduate Studies and Continuing Education, Wells House, 1 Union Ave., Union College, Schenectady, NY 12308 - (518) 370-6288.

INSTRUMENTATION, MEASUREMENTS ENGINEERING AND APPLICATION

Dates: July 16-20, 1979
Place: Union College, Schenectady, New York
Objective: Major topics will include transducer design, application and limitations, engineering the test program, recording techniques, identifying good and bad data, data reduction and interpretation, and case histories. These will be applied both to static and dynamic measurements.

Contact: Office of Graduate Studies and Continuing Education, Wells House, 1 Union Ave., Union College, Schenectady, NY 12308 - (518) 370-6288.

FRACTURE MECHANICS II WITH INDUSTRIAL APPLICATIONS

Dates: July 23-26, 1979
Place: Union College, Schenectady, New York
Objective: This course is designed for engineers with responsibility and management of fracture analysis and prevention. The course will focus on concepts and methods representing the state-of-the-art as applied in the pressure vessel and piping fields.

Contact: Office of Graduate Studies and Continuing Education, Wells House, 1 Union Ave., Union College, Schenectady, NY 12308 - (518) 370-6288.

WORKSHOP FOR THE ANALYSIS OF ROTOR BEARING SYSTEMS

Dates: July 23-27, 1979
Place: Union College, Schenectady, New York
Objective: A comprehensive survey of the dynamic problems of high speed, flexible rotors will be presented. A full range of rotor-dynamic phenomena will be examined; discussion of theory will be complemented by sample computations of realistic engineering problems.

Contact: Office of Graduate Studies and Continuing Education, Wells House, 1 Union Ave., Union College, Schenectady, NY 12308 - (518) 370-6288.

FINITE ELEMENT METHOD IN MECHANICAL DESIGN

Dates: July 23-27, 1979
Place: University of Michigan

Objective: Applications of the finite element method to practical problems of stress analysis and design are covered. Also included is the derivation of the method from energy principles. Graphics used for data preparation and interpretation of results will be presented.

Contact: Engineering Summer Conferences, 200 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109.

COMPUTER WORKSHOP IN EARTHQUAKE AND STRUCTURAL DYNAMICS

Dates: July 30-August 3, 1979
Place: Union College, Schenectady, New York
Objective: This course will cover structural dynamics techniques for both linear and nonlinear many-degree-of-freedom systems; and random vibration and computer graphics for input generation and output generation. Applications to current technological problems, including earthquake analysis, pipe whip dynamics, shock response of electronic cabinets, and fluid-solid interaction, will be discussed.

Contact: Office of Graduate Studies and Continuing Education, Wells House, 1 Union Ave., Union College, Schenectady, NY 12308 - (518) 370-6288.

AUGUST

THE SCIENTIFIC AND MATHEMATICAL FOUNDATIONS OF ENGINEERING ACOUSTICS

Dates: August 13-24, 1979
Place: Massachusetts Institute of Technology
Objective: The program emphasizes those parts of acoustics -- the vibration of resonators, properties of waves in structures and air -- the generation of sound and its propagation that are important in a variety of fields of application. The mathematical procedures that have been found useful in developing the desired equations and their solutions, and the processing of data are also studied. These include complex notation, fourier analysis, separation of variables, the use of special functions, and spectral and correlation analysis.

Contact: Richard H. Lyon, Massachusetts Institute of Technology, Room 3-366, Dept. of Mech. Engrg., Cambridge, MA 02139.

FINITE ELEMENT APPLICATIONS IN MACHINE DESIGN

Dates: August 27-31, 1979
Place: Tennessee Technological University
Objective: The course will cover basic theories of finite element techniques for force, displacement, and stress-related problems of mechanics and their applications to the solution of problems in the designs of mechanical systems, machines, and their components. Planar and three-dimensional flexural finite line elements; planar triangular, rectangular, quadrilateral and polar finite stress elements; three-dimensional tetrahedron, hexahedron, prism and polar finite stress elements; and rectangular and triangular finite plate elements will be presented.

Contact: Dr. Cemil Bagci, Dept. of Mech. Engrg., Tennessee Technological University, Cookeville, TN 38501 - (615) 528-3265/528-3254.

MACHINERY VIBRATIONS COURSE

Dates: August 28-30, 1979
Place: Anchorage, Alaska
Objective: This course on machinery vibrations will cover physical/mathematical descriptions, calculations, modeling, measuring, and analysis. Machinery vibrations control techniques, balancing, isolation, and damping, will be discussed. Techniques for machine fault diagnosis and correction will be reviewed along with examples and case histories. Torsional vibration measurement and calculation will be covered.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

SEPTEMBER

MACHINERY VIBRATION ANALYSIS

Dates: September 5-7, 1979
Place: Atlantic City, New Jersey
Dates: December 11-13, 1979
Place: New Orleans, Louisiana
Objective: The topics to be covered during this course are: fundamentals of vibration; transducer concepts; machine protection systems; analyzing vibration to predict failures; balancing; alignment; case histories, improving your analysis capability;

managing vibration data by computer; and dynamic analysis.

Contact: Spectral Dynamics Corp. of San Diego, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

ROTATING MACHINERY VIBRATIONS SEMINAR

Dates: September 18-20, 1979
Place: Boxborough, Massachusetts
Objective: This seminar will feature lectures on fluid film bearings, torque induced lateral vibration, coupling use on rotating machinery, minicomputer use and self-excited vibrations in rotating machinery. Practical aspects of rotating machines will be emphasized.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

DIGITAL SIGNAL PROCESSING

Dates: September 18-20, 1979
Place: Washington, D.C.
Objective: This seminar covers theory, operation and applications -- plus additional capabilities such as transient capture, amplitude probability, cross spectrum, cross correlation, convolution coherence, coherent output power, signal averaging and demonstrations.

Contact: Spectral Dynamics Corp. of San Diego, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

OCTOBER

VIBRATION CONTROL

Dates: October 8-12, 1979
Place: The Pennsylvania State University
Objective: The seminar will be of interest and value to engineers and scientists in industry, government, and education. Topics include dynamic mechanical properties of viscoelastic materials; structural damping; isolation of machinery vibration from rigid and nonrigid substructures; isolation of impact transients; reduction of vibration in beams, plates, and shells; reduction of the flow-induced vibration of complex structures; case histories in vibration reduction; and characteristics of multi-resonant vibrators.

Contact: Professor John C. Snowdon, Seminar Chairman, Applied Research Lab., The Pennsylvania State University, P.O. Box 30, State College, PA 16801 - (814) 865-6364.

ROTATING MACHINERY VIBRATIONS COURSE

Dates: October 29-November 1, 1979
Place: Cherry Hill, New Jersey
Objective: This advanced course on rotating machinery vibrations will cover physical/mathematical modeling, mathematical computations, physical descriptions of vibration parameters, measuring, and analysis. Machinery vibrations control techniques will be discussed. Torsional vibration measurement, analysis, and control will be reviewed.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

NOVEMBER

VIBRATION DAMPING

Dates: November 5-8, 1979
Place: University of Dayton Research Institute
Objective: Topics to be covered are: damping behavior of materials, response measurements of damped systems, surface damping treatments on vibrating members, discrete damping devices, special analytical problems, increasing linear viscoelastic material properties, damping of acoustic vibrations, selected case histories, problem solving sessions, and demonstration of digital fast fourier analyses.

Contact: Mrs. Audrey G. Sachs, University of Dayton Research Institute, Dayton, OH 45469 - (513) 229-2919.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

ANNOUNCEMENT AND CALL FOR PAPERS

Symposium on
Computational Methods in Nonlinear Structural and Solid Mechanics
October 6-8, 1980

This symposium will be held at the Sheraton National Motor Hotel in Washington, D.C. and will be co-sponsored by The George Washington University and NASA Langley Research Center.

The purpose of the symposium is to provide multi-disciplinary medium for communicating recent and projected advances in numerical analysis, applied mechanics, computer hardware, computer software and their impact on the modeling and solution of nonlinear structural and solid mechanics problems. Papers are invited on the following topics: continuum basis for nonlinear phenomenon, material characterization and strength theories, computational strategies and adaptive methods, special requirements for nonlinear software systems, potential of minicomputers, supercomputers, distributed processors and microprocessors for nonlinear analysis. Among the application areas considered are: vehicle crashworthiness, reinforced concrete and fibrous composite structures, earthquake resistant structures and nuclear reactor design.

Authors should submit three copies of an extended abstract of about 1,000 words prior to November 2, 1979. Three copies of the final manuscript will be due by April 28, 1980. Papers accepted for presentation will be published before the meeting in a bound volume and will be considered for publication in the Journal of Computers and Structures.

One page abstracts are also solicited on current research in progress for presentations at special sessions. For further information contact: Professor Ahmed K. Noor, Mail Stop 246, The George Washington University, NASA Langley Research Center, Hampton, Virginia 23665 - Tel. (804) 827-2897.

ACOUSTICAL SOCIETY NEWS

The latest American National Standard, which is available from the Acoustical Society of America is ANSI S1.25-1978: American National Standard Specification for Personal Noise Dosimeters. Working Group S1-45, under the leadership of Kenneth M. Eldred, produced this new standard which will help users to obtain more uniform results when using noise dosimeters.

The first Standards Catalog that the Society has published is available. The draft document on E-weighting, draft ANSI Standard S1.27, American National Standard E-Weighting Network for Noise Measurement will be available only until August 1979.

The new report by the ANSI Standards Planning Panel on Noise Abatement and Control is also listed in the Standards Catalog.

For further information contact: Ms. Avril Brenig, Standards Manager, Acoustical Society of America, 335 East 45th Street, New York, NY 10017 - Tel. (212) 661-9404.

MECHANICAL FAILURES PREVENTION GROUP TO HOLD 29th SYMPOSIUM

May 23-25, 1979

The 29th MFPG Symposium on "Advanced Composites: Design and Applications" will be held at Gaithersburg, Maryland, May 23-25, 1979.

May 23, 1979

Session No. 1: *Aerospace and Aircraft Applications & Design (I)*

Chairman: Jesse E. Stern

"Characterization and Application of Advanced Composite Materials"

"Physical and Mechanical Response of Graphite --

Polymide Materials to Long Term Exposure in a Space Environment: Material Preparation and Control Testing"

"Effects of Room Temperature Ageing on Composite Prepregs"

Session No. 2: Aerospace and Aircraft Applications & Design (II)
Chairman: Sherman Johnsen

"Application of Instrumental Techniques in the Study of the Cure of Phthalocyanine/Graphite Fiber Composites"

"Moisture Diffusion Analysis for Composite Micro-Damage"

"Techniques and Application of Moisture Barriers to Graphite Epoxy Composites"

Session No. 3: Aerospace and Aircraft Applications and Design (III)
Chairman: Charles Ueng

"In Service Ultrasonic Inspection Systems for Composites"

"Design Considerations for Graphite Epoxy Laminates of Low Thermal Expansion"

"Aircraft Composite Material Selection and Application"

Session No. 4: Aerospace and Aircraft Applications and Design (IV)
Chairman: John Scialdone

"Development of a Library Module for the Analysis of Advanced Composite Materials"

"Environmental Effects of Composites During Burn and Explode"

"Development of a Spacecraft Precision Mounting Platform"

May 24, 1979

Session No. 5: Automotive Applications & Design
Chairman: Walter Gunkel

"Design Analysis of Automotive Composite Structures"

"Use of Composites in Automotive Applications"

"Designing with Continuous Reinforced Composites"

Session No. 6: Industrial Applications & Design
Chairman: Anton Hehn

"Fabrication of Large Composite Spars and Blades"

"Design Parameters vs. Fiber Orientation of Reinforced Thermoplastics"

"Quality Assurance of Manufactured Composites"

Session No. 7: Industrial Applications & Design
Chairman: Charles O. Smith

"Degradation Data of Kevlar Pressure Vessels"

"Design Assurance of a Leak Failure Mode for Composite Overwrapped Metal Tankage"

"Composite Materials in Recreational Equipment"

Session No. 8: Industrial Applications & Design"
Chairman: Robert Maringer

"Holographic Nondestructive Evaluation of Spherical Kevlar Epoxy Pressure Vessels"

"Manufacturing Cost/Design Guide"

"Tensile Strength and Failure Modes of Boron Epoxy Composites with a Notch"

May 25, 1979

Session No. 9: Failure Modes in Advanced Composites
Chairman: Geza Kardos

"Failure Criteria for Composites Under Complex Loading"

"Failure Analysis of an Idealized Composite Damage Zone"

"Interlaminar Failure in Epoxy Based Composite Laminates"

Session No. 10: Marine Applications and Design
Chairman: Maurice Silvergleidt

"Design and Application; Advanced Composite Materials"

"Environmental Effects on Fiber Reinforced Organic Matrix Composites"

"Composite Technology for Marine Application"

For further information contact: J.E. Stern, Code 721, Goddard Space Flight Center, Greenbelt, MD 20771 - Tel. (301) 344-7657.

RANDOM VIBRATION DEMONSTRATIONS VIDEOTAPED

Increased acceptance for random vibration testing is seen as a result of videotaping. Viewers can now see just what random vibration is, also how structures respond to random vibration as compared to sinusoidal vibration, according to Wayne Tustin, Tustin Institute of Technology, Santa Barbara, CA.

Four vibration demonstration sequences have been taped, showing various aspects of sinusoidal and random vibration testing, measurement and analysis. These sequences are being used in Tustin's "open" courses to which individuals are sent, also in "closed" courses such as Tustin teaches for employees of a host organization.

One videotaped sequence features shaker forcing of a model that consists of two cantilevered metal reeds about 6 inches long. When the assembly is vibrated sinusoidally, with the forcing frequency sweeping 5 to 100 Hz, only one reed responds at a time, the thin one at 17 Hz and the thicker one at 36 Hz. Because of their relative position, the reeds do not strike. However, with broad-spectrum 5 to 100 Hz random vibration (containing all forcing frequencies in that range), the reeds respond simultaneously and strike each other. Thus they exhibit a "failure" mode not found with sinusoidal forcing. The reeds might represent an array of printed circuit boards; such arrays often pass sinusoidal tests but fail in service or during random tests. This 11-minute sequence may be borrowed for a $10 handling charge.

Write to 22 East Los Olivos Street, Santa Barbara, California 93105 or call (805) 682-7171.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALYTICAL METHODS

79-711

On Non-Linear Oscillations with Slowly Varying System Parameters

S.C. Sinha and C.C. Chou
Dept. of Mech. Engrg., Kansas State Univ., Manhattan, KS 66506, J. Sound Vib., 61 (2), pp 293-301 (Nov 22, 1978) 2 figs, 11 refs

Key Words: Approximation methods, Nonlinear response

The paper deals with an approximate analysis of nonlinear oscillation problems with slowly varying system parameters. From the differential equations for amplitude and phase, set up by the method of variation of parameters, the approximate solutions are obtained by using the generalized averaging method of Sinha and Srinivasan based on ultraspherical polynomial expansions. The Bogoliubov-Mitropolsky results are given by a particular set of these polynomials. Problems of a single degree of freedom system as well as monofrequency oscillations in systems with multiple degrees of freedom are considered. The approach is illustrated by an example and the results are compared with the numerical solutions. A close agreement is found.

79-712

Synthesis of Lumped-Parameter Vibrating Systems in Which Elemental Stiffness May be Varied

J.H. Hibbert
Dept. of Aeronautical and Mech. Engrg., Univ. of Salford, Salford M5 4WT, UK, J. Sound Vib., 61 (2), pp 161-167 (Nov 22, 1978) 3 figs, 4 refs

Key Words: Lumped parameter method, Structural synthesis, Natural frequency, Mode shapes

The paper describes a method of synthesizing the stiffnesses of the elastic elements in linear lumped-parameter vibrating systems so that one mode has a prescribed natural frequency and mode shape. A least squares solution can be evaluated and used as a basis for obtaining a general solution in the form of a linear combination of a number of linearly independent vectors. This type of solution is found to be particularly convenient when additional optimization is to be carried out on the system being considered.

79-713

Dynamic Stress Concentration Around Two Coplanar Griffith Cracks in an Infinite Elastic Medium

S. Itou
Dept. of Mech. Engrg., Hachinohe Inst. of Tech., Hachinohe 031, Japan, J. Appl. Mech., Trans. ASME, 45 (4), pp 803-806 (Dec 1978) 3 figs, 3 tables, 7 refs

Key Words: Cracked media

The dynamic problem presented here is for an infinite elastic medium weakened by two coplanar Griffith cracks in which a self-equilibrated system of pressure is varied harmonically with time. The problem is reduced to dual integral equations and solved by a series-expansion method. The dynamic stress-intensity factors are computed numerically.

79-714

Three-Dimensional Wave Propagation in a Cracked Elastic Solid

S. Itou
Dept. of Mech. Engrg., Hachinohe Inst. of Tech., Hachinohe 031, Japan, J. Appl. Mech., Trans. ASME, 45 (4), pp 807-811 (Dec 1978) 3 figs, 3 tables, 7 refs

Key Words: Cracked media, Discontinuity-containing media, Wave diffraction

The three-dimensional dynamic problem is presented for an infinite elastic medium weakened by a plane crack of infinite length and finite width. On the surfaces of the crack, the self-equilibrated system of a load varies harmonically in time and is distributed arbitrarily on those surfaces. The Fourier transformations are utilized to reduce the problem to a solution of two simultaneous integral equations which can be solved by using the series expansion method. The dynamic stress-intensity factor is computed numerically for some applied loads.

NUMERICAL ANALYSIS

79-715

A Numerical-Experimental Investigation of Dynamic Fracture

S. Mall
Ph.D. Thesis, Univ. of Washington, 229 pp (1977)
UM 7814467

Key Words: Fracture properties, Photoelastic analysis, Numerical analysis

Investigation of dynamic fracture is undertaken with the help of dynamic photoelasticity and numerical analysis. A dynamic finite element algorithm is developed for computing the dynamic stress intensity factors from the experimentally determined crack position versus time relation of a propagating and arresting crack. The accuracy of the developed numerical procedure is checked by a comparative study with a theoretical solution and by comparing the numerically determined stress intensity factors with those determined from photoelastic experiments. An application of the developed numerical procedure is demonstrated in the investigation of three phases of dynamic fracture: initiation, propagation, and arrest.

79-716

Roots of Lambda Matrices

G.A. Thurston

Dept. of Mech. Engrg., Univ. of Colorado at Denver, CO, J. Appl. Mech., Trans. ASME, 45 (4), pp 859-863 (Dec 1978) 1 fig, 2 tables, 9 refs

Key Words: Numerical analysis, Matrix methods, Beams, Frames

A numerical method is outlined for computing roots of determinants of lambda matrices. Convergence of the method is quadratic as long as the derivative of the determinant does not vanish at the root. When the derivative is zero, the method may still converge is special cases. Three examples of mechanics problems (beam and frame vibrations, nonlinear vibrations, and equations with periodic coefficients) giving rise to lambda matrices are included.

STABILITY ANALYSIS

79-717

Mathieu Stability Analysis of Non-Linear Third-Order Weakly Forced Systems

R.N. Tiwari and R. Subramanian

Dept. of Electrical Engrg., Motilal Nehru Regional Engrg. College, Allahabad-211004, India, J. Sound Vib., 61 (1), pp 113-116 (Nov 8, 1978) 6 refs

Key Words: Stability methods

A Mathieu type of stability analysis for evaluating the stability of singular points having a periodic solution is presented.

FINITE ELEMENT MODELING

(Also see Nos. 723, 801, 802)

79-718

The Accuracy and Stability of Time Domain Finite Element Solutions

G.F. Howard and J.E.T. Penny

Dudley Tech. College, West Midlands, UK, J. Sound Vib., 61 (4), pp 585-595 (Dec 22, 1978) 3 tables, 4 refs

Key Words: Finite element technique, Time-dependent parameters

A means of determining the response of a mechanical system to any forcing function by the use of finite elements in the time domain is provided. Two types of elements are used; a cubic element which maintains continuity of displacement and velocity between adjacent elements, and a quintic element which also ensures continuity of acceleration. A condition for the stability of a solution is also established.

MODELING

(See No. 876)

PARAMETER IDENTIFICATION

(Also see Nos. 725, 733)

79-719

Determining Models of Structures from Earthquake Records

J.L. Beck

Ph.D. Thesis, California Inst. of Technology, 309 pp (1979)

UM 7824370

Key Words: Parameter identification technique, System identification technique, Seismic response spectra, Mathematical models

The problem of determining linear models of structures from seismic response data is studied using the theory of system identification. The investigation employs a general formulation called the output-error approach, in which optimal estimates of the model parameters are obtained by minimizing a selected measure-of-fit between the responses of the structure and the model. It is shown that it is necessary in practice to estimate parameters of the dominant modes in the records, rather than the stiffness and damping matrices. Two output-error techniques are investigated: an optimal filter method and the modal minimization method.

CRITERIA, STANDARDS, AND SPECIFICATIONS

79-720

Model Municipal Noise Control By-Law

Ministry of the Environment, Ontario, Canada, (Aug 1978) Avail: Ontario Govt. Bookstore, 880 Bay St., Toronto, Canada M7A 1N8

Key Words: Regulations, Noise reduction, Urban noise

An amendment to the Canadian Environmental Protection Act was passed in 1975. It permits local municipalities to pass noise control by-laws for the protection and conservation of the natural environment, subject to the approval of the Minister of the Environment.

SURVEYS AND BIBLIOGRAPHIES

79-721

Wind Effects. Part 1. Buildings and Bridges (Citations from the Engineering Index Data Base)

G.E. Habercom, Jr.

National Technical Information Service, Springfield, VA, NTIS/PS-78/1209/2GA, 286 pp (Nov 1978)

Key Words: Bibliographies, Buildings, Bridges, Wind-induced excitation

Dynamic structural response of buildings and bridges to wind pressure and gust loads are investigated in these reports gathered from a worldwide literature survey. This updated bibliography contains 281 abstracts, 39 of which are new entries to the previous edition.

79-722

Wind Effects. Part 1. Buildings and Bridges (Citations from the NTIS Data Base)

G.E. Habercom, Jr.

National Technical Information Service, Springfield, VA, NTIS/PS-78/1207/6GA, 176 pp (Nov 1978)

Key Words: Bibliographies, Buildings, Bridges, Wind-induced excitation

Dynamic structural responses of buildings and bridges to wind pressure and gust loads are investigated in these Government-sponsored research reports. Residential buildings, skyscrapers, and bridge structures exposed to winds are studied. This updated bibliography contains 171 abstracts, 15 of which are new entries to the previous edition.

79-723

Shock and Vibration Analysis Using Finite Element Techniques

T.V. Seshadri

Fruehauf Corp., Detroit, MI, Shock Vib. Dig., 10 (12), pp 3-9 (Dec 1978) 3 figs, 41 refs

Key Words: Reviews, Finite element technique

This paper reviews current state of the art in shock and vibration analyses using finite element techniques. The development of a total finite element model using a combination of analytical and experimental techniques is described.

79-724

A Review of the Theory of Trailing Edge Noise

M.S. Howe

Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, J. Sound Vib., 61 (3), pp 437-465 (Dec 8, 1978) 6 figs, 38 refs

Key Words: Reviews, Sound generation, Plates, Fluid-induced excitation

A critical review is presented of the literature on the theory of the generation of sound by the interaction of low Mach number turbulent flow with the edge of a semi-infinite rigid plate. Three distinct approaches to the subject are identified, consisting of theories based on Lighthill's acoustic analogy, the solution of special, linearized hydroacoustic problems, and ad hoc aerodynamic source models.

79-725

Parameter Identification Techniques for Vibrating Structures

A. Berman

Kaman Aerospace Corp., Bloomfield, CT, Shock Vib. Dig., 11 (1), pp 13-16 (Jan 1979) 35 refs

Key Words: Reviews, Parameter identification technique

A brief description of mathematical formulations of a vibrating structure is presented. Several categories of parameter identification are described. Related works published in the past several years are categorized. Surveys covering earlier contributions are referenced.

79-726

Evaluation of Stiffness and Damping Coefficients for Fluid-Film Bearings

J.W. Lund

Dept. of Machine Elements, Technical Univ. of Denmark, Lyngby, Denmark, Shock Vib. Dig., 11 (1), pp 5-10 (Jan 1979) 34 refs

Key Words: Reviews, Fluid-film bearings, Stiffness coefficients, Damping coefficients

Methods for calculating fluid film bearing stiffness and damping coefficients are briefly described. Restrictions imposed by such assumptions as linearity are evaluated. Experimental methods used to obtain data necessary to determine the coefficients are presented.

79-727

A Sketch of Aeroacoustics

R.E.A. Arndt

St. Anthony Falls Hydraulic Lab., Mississippi River at 3rd Ave., S.E., Univ. of Minnesota, Minneapolis, MN 55414, Shock Vib. Dig., 10 (12), pp 11-19 (Dec 1978) 10 figs, 6 refs

Key Words: Reviews, Aircraft noise, Jet noise, Rotor blades (rotary wings)

This article reviews the state of the art in aeroacoustics. Aircraft noise sources are summarized. Two major noise sources – jet noise and noise from rotating blades – are described in detail. Research trends are mentioned.

79-728

Finite Element Modeling of Structural Vibrations: A Review of Recent Advances

J.N. Reddy

School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Oklahoma, Norman, OK 73019, Shock Vib. Dig., 11 (1), pp 25-39 (Jan 1979) 211 refs

Key Words: Reviews, Finite element technique, Structural elements, Beams, Plates, Shells

This review of research in the finite element modeling of structural vibrations concentrates on literature published on the vibrations of the basic structural elements, namely, beams, plates, and shells since 1967.

79-729

Recent Research in Plate Vibrations. 1973-1976: Complicating Effects

A.W. Leissa

Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH, Shock Vib. Dig., 10 (12), pp 21-35 (Dec 1978) 175 refs

Key Words: Reviews, Plates, Vibration response

This paper is a review of literature dealing with the complicating effects of free, undamped vibrations of plates that appeared from 1973-1975 and in part of 1976. Recent research dealing with the complicating effects of anisotropy, in-plane forces, variable thickness, surrounding media, large deflections, shear deformation, rotary inertia, and nonhomogeneity (including layered plates) is summarized.

79-730

Noise Characteristics of Axial and Centrifugal Fans as Used in Industry - A Review

B.D. Mugridge

British Gas Corp., Res. & Dev. Div., Midlands Research Station, Wharf Lane, Solihull, West Midlands B91 2JW, UK, Shock Vib. Dig., 11 (1), pp 17-24 (Jan 1979) 57 refs

Key Words: Reviews, Fans, Noise generation, Noise prediction, Noise reduction

This review is aimed at the industrial engineer. Basic noise-generating mechanisms are reviewed. Overall fan noise prediction techniques are discussed. Various techniques that have proven useful for reducing noise at the source are described. The specialized reader will find references to some of the more recent contributions – including those for high-speed machinery – that have been published since 1975.

TUTORIAL

79-731

NSF-DCPA-ASEE Summer Institute on Multiprotection Design (1977)

American Society for Engineering Education, Washington, D.C., Rept. No. NSF/RA-770633, 25 pp (Aug 5, 1977)
PB-286 519/4GA

Key Words: Design techniques, Seismic design, Wind-induced excitation

The objectives of this program are to present to architectural and engineering faculty and practitioners the current problems and approaches to the design of structures to both protect the occupants and to mitigate the effects of natural disasters such as ground motion earthquakes, high winds, tornadoes, hurricanes, and fire. Included would be building design, considerations for nuclear blast and radiation fallout, environmental considerations, security and crime, and energy conservation.

79-732

Research Needs and Priorities for Geotechnical Earthquake Engineering Applications

K.L. Lee, W.F. Marcuson, K.H. Stoke, and F.Y. Yokel
Texas Univ. at Austin, TX, Rept. No. NSF/RA-780223, NSF-AEN77-09861, 150 pp (1978)
PB-286 142/5GA

Key Words: Soils, Dynamic properties, Measurement techniques, Mathematical models, Seismic design, Interaction: soil-structure, Test models

The workshop was held to discuss research needs and priorities in geotechnical earthquake engineering. Group discussions involved the following topics: dynamic soil properties and measurement techniques in the laboratory; dynamic soil properties and measurement techniques in the field; analytical procedures and mathematical modeling; design earthquakes, ground motion, and surface faulting; assessment of seismic stability of soil; soil structure interaction; and experimental modeling and simulation. The workshop recommended that applied research be carried out to: improve understanding of basic fundamentals; improve design methods; evaluate and verify the design procedures; and transfer technology.

MODAL ANALYSIS AND SYNTHESIS

(Also see Nos. 741, 742, 901)

79-733

Methods for Determining Modal Parameters and Mass, Stiffness and Damping Matrices

C.L. Keller
Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH 45433, Rept. No. AFFDL-TR-78-59, 77 pp (June 1978)
AD-A058 788/1GA

Key Words: Modal analysis, Parameter identification technique, Mass matrices, Stiffness coefficients, Damping coefficients, Computer programs

Methods for determining modal parameters and mass, damping and stiffness matrices from vibration tests are described mathematically. The emphasis is on methods which are capable of determining the desired quantities from excitations at a single point. A method which determines the modal parameters and the mass, damping and stiffness matrices from the steady-state response to sinusoidal excitations is proposed. A computer program of this method and the results of two numerical experiments are given. The mathematical background for all the methods is given.

79-734

Transient Response of Structures by Use of Component Modes

J.M. Klosner and D. Ranlet
Weidlinger Associates, NY, Rept. No. TR-22, 46 pp (Feb 1978)
AD-A059 002/6GA

Key Words: Transient response, Component mode analysis

A general method is presented for obtaining the dynamic equations of an elastic structure to which elastic and/or nonlinear substructural elements are attached.

79-735

A Simple Method for Designing Structural Models with Closely Spaced Modes of Vibration

W.L. Hallauer, Jr., T.A. Weisshaar, and A.G. Shostak
Dept. of Aerospace and Ocean Engrg., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 61 (2), pp 245-254 (Nov 22, 1978) 5 figs, 2 tables, 6 refs
Sponsored by NASA Langley Res. Center

Key Words: Mathematical models, Modal analysis

In this paper, a method for designing a mathematical structural model having closely spaced modes is presented and illustrated with examples. Given a reference model with specified geometry and degrees of freedom, the lumped inertias and stiffnesses of the model are perturbed in such a manner as to force together two of its natural frequencies. With a slight alteration, the method is also applicable to the inverse problem of separating undesirable closely spaced modes which appear in a structural design.

COMPUTER PROGRAMS

GENERAL

(Also see No. 862)

79-736

Derivation of the Equations of Motion for Complex Structures by Symbolic Manipulation

A.L. Hale and L. Meirovitch
Dept. of Engrg. Science and Mech., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, Computers Struc., 9 (6), pp 639-649 (Dec 1978) 2 figs, 10 refs

Key Words: Equations of motion, Computer programs

This paper outlines a computer program tailored to the task of deriving explicit equations of motion for structures with point-connected substructures. The special purpose program is written in FORTRAN and is designed for performing the specific algebraic operations encountered in the derivation of explicit equations of motion. The derivation is by the Lagrangian approach. Using an orderly kinematical procedure and a discretization and/or truncation scheme, it is possible to write the kinetic and potential energy of each substructure in a compact vector-matrix form.

79-737

The Airport Noise Prediction Model - MOD 7

R.H. Hinckley and W. Messcher
Transportation Systems Center, Cambridge, MA, Rept. No. DOT-TSC-RSPA-78-19, 186 pp (July 1978)
PB-285 789/4GA

Key Words: Computer programs, Mathematical models, Aircraft noise, Airports, Noise prediction

The MOD 7 Airport Noise Prediction Model is fully operational. The language used is Fortran, and it has been run on several different computer systems. Its capabilities include prediction of noise levels for single parameter changes, for multiple changes, and for an entire airport's operations. Some of the single parameters include: type of aricraft, flight paths, speed, thrust, and noise abatement procedures. (Portions of this document are not fully legible).

79-738

Seventh NASTRAN User's Colloquium

Marshall Space Flight Center, NASA, Huntsville, AL, Rept. No. NASA-CP-2062, 499 pp (Oct 1978)
N78-32466

Key Words: NASTRAN (computer program), Computer programs, Finite element technique

The general application of finite element methodology and the specific application of NASTRAN to a wide variety of static and dynamic structural problems are described. Topics include: fluids and thermal applications, NASTRAN programming, substructuring methods, unique new applications, general auxiliary programs, specific applications, and new capabilities.

79-739

Development of Structural Dynamic Test Environments for Subsystems and Components

R.J. Coladonato
Goddard Space Flight Center, NASA, Greenbelt, MD, In: NASA, Marshall Space Flight Ctr., 7th NASTRAN User's Colloq., pp 85-110 (Oct 1978)
N78-32473

Key Words: NASTRAN (computer program), Computer programs, Finite element technique, Dynamic tests

Structural dynamic environmental test levels are developed for the thematic mapper instrument, components of the Tandberg-Hanssen instrument, and components of the International Ultraviolet Explorer spacecraft using NASTRAN structural models and test data. Both static and dynamic NASTRAN analyses are used. The model size required could be as small as 300 degrees of freedom for the static analysis and as large as 4000 degrees of freedom or more for the high frequency dynamic analysis. An important step in the development of the levels is model verification by test. The launch environments that generally dictate many important features of the design of an instrument or component are steady state acceleration, sinusoidal vibration, and random vibration.

79-740
Modeling Structural Damping for Solids Having Distinct Shear and Dilatational Loss Factors

A.J. Kalinowski
Naval Underwater Systems Center, New London, CT,
In: NASA, Marshall Space Flight Ctr., 7th NASTRAN User's Colloq., pp 193-205 (Oct 1978)
N78-32478

Key Words: NASTRAN (computer program), Computer programs, Finite element technique, Internal damping, Damping coefficients

For steady state time harmonic problems, the NASTRAN program (rigid format 8), treats internal structural damping through the introduction of a single structural element damping coefficient that typically is viewed as the ratio of the complex to real modulus of elasticity. A technique is presented whereby the user can adapt the standard versions of NASTRAN (without resorting to either DMAP and/or FORTRAN coding changes) for the purpose of treating this class of problem.

79-741
Dynamic Analysis Using Superelements for a Large Helicopter Model

M.P. Patel and L.C. Shah
Hughes Helicopters, Culver City, CA,
In: NASA, Marshall Space Flight Ctr., 7th NASTRAN User's Colloq., pp 335-354 (Oct 1978)
N78-32486

Key Words: NASTRAN (computer program), Computer programs, Finite element technique, Component mode synthesis, Modal analysis, Frequency response, Helicopters, Beams

Using superelements (substructures), modal and frequency response analysis is performed for a large model of the Advanced Attack Helicopter developed for the U.S. Army. Whiffletree concept is employed so that the residual structure along with the various superelements can be represented as beam-like structures for economical and accurate dynamic analysis. A very large DMAP alter to the rigid format is developed so that the modal analysis, the frequency response, and the strain energy in each component can be computed in the same run.

79-742
Accuracy of Results with NASTRAN Modal Synthesis

D.N. Herting
Universal Analytics, Inc., Los Angeles, CA,
In: NASA, Marshall Space Flight Ctr., 7th NASTRAN User's Colloq., pp 389-404 (Oct 1978)
N78-32489

Key Words: NASTRAN (computer program), Computer programs, Component mode synthesis, Modal synthesis

A new method for component mode synthesis is developed for installation in NASTRAN level 17.5. Results obtained from the new method are presented, and these results are compared with existing modal synthesis methods.

79-743
Transients by Substructuring with DMAP

T.G. Butler
Marshall Space Flight Ctr., NASA, Huntsville, AL,
In: NASA, Marshall Space Flight Ctr., 7th NASTRAN User's Colloq., pp 301-333 (Oct 1978)
N78-32485

Key Words: NASTRAN (computer program), Computer programs, Finite element technique, Transient response

Automated substructuring in level 16 of NASTRAN is employed as a preface to the solution of a direct transient analysis. The DMAP ALTER statements written to adapt the substructuring for transient purposes are explained. Data recovery is accomplished with transfer functions. Proof of the success of the method is presented with an application to a missile structure.

79-744

Extension of the Tridiagonal Reduction (FEER) Method for Complex Eigenvalue Problems in NASTRAN

M. Newman and F.I. Mann

Business and Technological Systems, Inc., Bowie, MD, In: NASA, Marshall Space Flight Ctr., 7th NASTRAN User's Colloq., pp 419-446 (Oct 1978)

N78-32491

Key Words: NASTRAN (computer program), Computer programs, Finite element technique, Eigenvalue problems

As in the case of real eigenvalue analysis, the eigensolutions closest to a selected point in the eigenspectrum are extracted from a reduced, symmetric, tridiagonal eigenmatrix whose order is much lower than that of the full size problem. The reduction process is effected automatically, and thus avoided the arbitrary lumping of masses and other physical quantities at selected grid points. The statement of the algebraic eigenvalue problem admitted mass, damping, and stiffness matrices which are unrestricted in character, i.e., they might be real, symmetric or nonsymmetric, singular or nonsingular.

79-745

DYGABCD: A Program for Calculating Linear A, B, C, and D Matrices from a Nonlinear Dynamic Engine Simulation

L.C. Geyser

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TP-1295; E-9464, 203 pp (Sept 1978)

N78-33110

Key Words: Computer programs, Turbofan engines, Turbine engines

A digital computer program, DYGABCD, is developed which generates linearized, dynamic models of simulated turbofan and turbojet engines. DYNGEN (an earlier computer program upon which DYGABCD is based) is capable of calculating simulated nonlinear steady-state and transient performance of one- and two-spool turbojet engines or two- and three-spool turbofan engines. The report discusses the analytical approach and provides a users manual, FORTRAN listings, and a sample case.

79-746

FORMAT - Fortran Matrix Abstraction Technique. Volume V. Supplement III. Engineering User and Technical Report - Extended

J. Pickard

Douglas Aircraft Co., Long Beach, CA, Rept. No. MDC-J7174, AFFDL-TR-66-207-VOL-5-SUP-3, 18 pp (May 1978)

AD-A059 172/7GA

Key Words: Computer programs, FORMAT (computer program), Matrix methods

The FORMAT system is augmented with new capabilities applicable to elastic stability and dynamic analyses and is modified to improve operating efficiency and user convenience. A new large order eigensolution module and a module to evaluate matrices representing specific forms of complex exponents of the natural logarithmic base are added. Efficiency improvements are made to the matrix multiply, transposition and decomposition modules. The decomposition module is modified to perform congruent transformations yielding the upper triangular form of the resulting matrix. The capability to create user defined leading diagonal or full rectangular matrices with constant element values is added to the matrix card input module. The capability of modifying available work space parameters with user input is also provided.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 720, 724, 737, 781, 782, 867)

79-747

New Scaling Laws for Hot and Cold Jet Mixing Noise Based on a Geometric Acoustics Model

C.L. Morfey, V.M. Szewczyk, and B.J. Tester

Inst. of Sound and Vib. Research, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 61 (2), pp 255-292 (Nov 22, 1978) 33 figs, 39 refs

Sponsored by the USAF

Key Words: Jet noise, Scaling

New scaling laws are presented for hot turbulent jet mixing noise outside the cone of silence. These account for mean flow field effects on sound radiation via an analytical high frequency approximate solution to Lilley's equation. Numerical calculations for sound radiation from sources in a cylindrical shear flow are used to test the validity of the approximation. The proposed scaling laws yield an excellent collapse of jet noise measurements over a wide range of conditions. The resulting information has been incorporated into a jet mixing noise prediction scheme which, with appropriate modifications to the analytical high frequency approximation, can be applied both inside and outside the cone of silence.

PERIODIC

79-748
Bifurcations in Dynamical Systems with Internal Resonance

P.R. Sethna and A.K. Bajaj
Dept. of Aerospace Engrg. and Mechanics, Univ. of Minnesota, Minneapolis, MN 55455, J. Appl. Mech., Trans. ASME, 45 (4), pp 895-902 (Dec 1978) 5 figs, 16 refs

Key Words: Dynamic systems, Periodic excitation, Resonant frequencies

Dynamical systems with quadratic nonlinearities and exhibiting internal resonance under periodic excitations are studied. Two types of transition from stable to unstable motions are shown to occur. One kind are associated with jump phenomena while the other kind are associated with Hopf bifurcations of the averaged system of equations.

RANDOM

79-749
The Response of an Oscillator with Bilinear Hysteresis to Stationary Random Excitation

J.B. Roberts
School of Engrg. and Appl. Sciences, Univ. of Sussex, Falmer, Brighton BN1 9QT, UK, J. Appl. Mech., Trans. ASME, 45 (4), pp 923-928 (Dec 1978) 8 figs, 18 refs

Key Words: Random excitation, Stochastic processes, Hysteretic damping

By applying the technique of stochastic averaging, a simple analytical result is obtained for the joint distribution of the displacement and velocity of a bilinear oscillator excited by a stationary random process. The theoretical results deduced from this distribution are compared with corresponding digital simulation results.

79-750
Stationary Response of a Randomly Parametric Excited Nonlinear System

R.A. Ibrahim
Arab Organization for Industrialization, Sakr Factory for Developed Industries, P.O. Box 33, Heliopolis, Cairo, Egypt, J. Appl. Mech., Trans. ASME, 45 (4), pp 910-916 (Dec 1978) 3 figs, 28 refs

Key Words: Parametric excitation, Random parameters, Nonlinear systems

This paper presents a review of three truncation schemes for the problem of the infinite hierarchy of moment equations and an investigation of the stationary response of a nonlinear system under a broad band random parametric excitation. The validity of the truncation methods is discussed together with the conditions for preservation of moment properties. One of these schemes is employed to truncate the dynamic moment equations of a nonlinear single-degree-of-freedom system subject to a broad band random parametric excitation. The influence of inertia, stiffness, and damping nonlinearities is discussed and closed-form solutions are obtained for each case.

SEISMIC

(Also see Nos. 719, 731, 853)

79-751
Seismic Analysis of Pipelines with Interference Response Spectra

P. Weidlinger and I. Nelson
Weidlinger Associates, NY, Rept. No. NSF/RA-780227, 70 pp (June 1978)
PB-285 726/6GA

Key Words: Interference response spectra, Seismic response, Pipelines, Bridges, Tunnels

In this paper, the concept of the Interference Response Spectrum (IR Spectrum) is discussed. The IR Spectrum presents quantitatively and in a unified form the effects of the non-coherent free field on the dynamic response of lifeline structures. Derivations, properties and examples of IR spectra are given. Further investigations for using IR Spectrum in seismic analysis are suggested.

79-752

Public Policy in Earthquake Effects Mitigation: Earthquake Engineering and Earthquake Prediction

M.L. Pate

Ph.D. Thesis, Stanford Univ., 425 pp (1978)
UM 7822556

Key Words: Seismic design, Earthquake prediction

The primary objective of this study is to provide a method of cost-benefit analysis under uncertainty of two major means of mitigation of earthquake effects: earthquake engineering and earthquake prediction. Earthquake engineering involves strengthening the structures at construction time or upgrading the existing buildings; the question is to evaluate its costs vs. the later avoided seismic losses. Earthquake prediction provides the society with information which allows it to take protection measures; the question is to assess the value of such information in a given state of prediction technology, thus an uncertainty over the accuracy of the predicted magnitude.

79-753

A Dynamic Source Model for the San Fernando Earthquake

M. Bouchon

Laboratoire de Geophysique Interne, Universite Scientifique et Medicale de Grenoble, Grenoble, France, Bull. Seismol. Soc. Amer., 68 (6), pp 1555-1576 (Dec 1978) 12 figs, 31 refs

Key Words: Earthquakes, Mathematical models

The San Fernando earthquake is modeled as a propagating rupture in a half-space, using for the slip-time-history on the fault plane analytical expressions which approximate the slip functions of dynamic crack models. The strong ground motions and accelerations at the Pacoima Dam site are synthesized and the teleseismic signals for different models of cracks are computed. Three major features of the data -- the strong pulse associated with the beginning of the rupture, the high acceleration phase on the Pacoima Dam records, and the presence of ripples on the teleseismic seismograms -- are explained.

SHOCK

(Also see No. 855)

79-754

Shock Formation Distance in Real Air

N.H. Johannesen and W.A. Scott

Dept. of the Mechanics of Fluids, Univ. of Manchester, Manchester M13 9PL, UK, J. Sound Vib., 61 (2), pp 169-177 (Nov 22, 1978) 5 figs, 14 refs

Key Words: Shock waves

A simple derivation of the shock formation distance in spherically symmetric, unsteady, non-equilibrium flow is presented. The one-dimensional unsteady flow and the ideal gas flows emerge as special cases. The results are applied to atmospheric air and the ambiguity and limitations of the shock formation concept are discussed.

79-755

Large Amplitude Shock-Wave Motion in Two-Dimensional, Transonic Channel Flows

T.C. Adamson, Jr., A.F. Messiter, and M.S. Liou

The Univ. of Michigan, Ann Arbor, MI, AIAA J., 16 (12), pp 1240-1247 (Dec 1978) 6 figs, 5 refs
Sponsored by the Naval Air Systems Command

Key Words: Shock wave propagation

Two-dimensional unsteady transonic channel flow with a shock wave is considered for the slowly varying time regime. Pressure oscillations, introduced downstream of the shock wave, cause the shock wave to oscillate; the case considered is that where the shock moves upstream to the throat, disappears, and then reappears as the downstream pressure first increases and then decreases. The subsequent shock-wave motion consists of oscillations either about the throat or about the original steady flow shock position, depending upon the values of various parameters. These two cases and the dividing case are illustrated with example calculations.

79-756

Ship Collision Tests with Floating Ship Models

M. Pakstys, D. Koenigsberg, and H. Sheets

Dept. of Ocean Engrg., Rhode Island Univ., Kingston, RI, Rept. No. NMRC-KP-183, 33 pp (Jan 1978)
PB-286 211/8GA

Key Words: Collision research (ships), Test models

This report describes laboratory collision tests with floating flexible ship models. The tests involve a striking ship model colliding at a right angle with a stationary vessel, struck ship. The collision testing system consists of a launcher device, ship guidance systems and the water tank facility. The shock response on the colliding ships is measured by accelerometers for a number of collision velocities of the striking ship.

PHENOMENOLOGY

COMPOSITE

79-757

Simulation of the Influence of Bonding Materials on the Dynamic Behavior of Laminated Composites

A.H. Nayfeh and E.A.M. Nassar

Air Force Materials Lab., AFML/LLP, Wright-Patterson AFB, OH 45433, J. Appl. Mech., Trans. ASME, 45 (4), pp 822-828 (Dec 1978) 5 figs, 2 tables, 7 refs

Key Words: Layered materials, Composite materials, Wave propagation

Two model analyses are constructed in order to determine the influence of bonding materials on the dynamic behavior of otherwise bilaminated composites. The geometric arrangement of the composite with the bond is treated as a special type of a trilaminated composite in which each of its major constituents is sandwiched between two bonding layers. In the first model, the recently developed continuum mixture theories of wave propagation in bilaminated composites are extended to treat the trilaminated composite. Details of the propagation process in the major components and also in the bonding layers are derived. In the second model, the entire effect of the bonds is treated as a modifier to interfacial continuity conditions. In this model the details of the propagation process in the bonding material are ignored. It is found that the results of both models correlate well for relatively thin bonding layers.

79-758

Harmonic Waves in Layered Composites: New Bounds on Eigenfrequencies

C.O. Horgan, K.-W. Lang, and S. Nemat-Nasser

Dept. of Engrg. Sciences and Appl. Mathematics, The Technological Inst., Northwestern Univ., Evanston, IL, J. Appl. Mech., Trans. ASME, 45 (4), pp 829-833 (Dec 1978) 2 figs, 4 tables, 17 refs

Key Words: Layered materials, Composite materials, Eigenvalue problems, Boundary value problems

The purpose of this paper is to present new approaches to the problem of wave frequency estimation for harmonic waves in layered elastic composites. Upper and lower bounds are obtained by adapting standard results for eigenvalue problems with smooth coefficients. The one-dimensional eigenvalue problem with discontinuous coefficients of concern here is first transformed by using an analog of the classical Liouville transformation. Upper bounds are obtained by application of a Rayleigh-Ritz technique to the transformed problem. Explicit lower bounds in terms of the coefficients are established. Results are illustrated by numerical examples.

DAMPING

(See No. 873)

ELASTIC

79-759

General Electromechanical Reciprocity Relations Applied to the Calculation of Elastic Wave Scattering Coefficients

B.A. Auld

Edward L. Ginzton Lab., Stanford Univ., Stanford, CA, Wave Motion, 1 (1), pp 3-10 (1979) 5 figs, 20 refs

Key Words: Wave diffraction, Elastic media

General electromechanical reciprocity relations are applied to the calculation of elastic wave scattering coefficients observed at the electrical terminals of the transducer used in performing an experiment. Both direct backscatter and two transducer geometries are considered. The general formulation is applicable to anisotropic media, but is applied as an example to Rayleigh wave scattering from a surface-breaking crack on an isotropic substrate. This method of analysis is applicable to both the Born and quasistatic approximations and is valid for bulk, Rayleigh and plate wave transducers using any single transduction mechanism.

79-760
Diffraction of an Evanescent Plane Wave by a Half Plane

G.A. Deschamps, S.W. Lee, E. Gowan, III, and T. Fontana
Electromagnetics Lab., Dept. of Electrical Engrg., Univ. of Illinois at Urbana-Champaign, Urbana, IL,
Wave Motion, 1 (1), pp 25-35 (1979) 9 figs, 8 refs
Sponsored by the National Science Foundation

Key Words: Wave propagation, Elastic media

A proper analytic continuation of Sommerfeld's solution is shown to provide the solution to the problem of diffraction of an evanescent plane wave. This is done by a correct extension of a parameter (detour parameter) from real to complex values. Some peculiarities of this solution are discussed. A few representative three-dimensional graphs show the field magnitude in the vicinity of the edge.

79-761
On the Influence of a Flexural Biasing State on the Velocity of Piezoelectric Surface Waves

B.K. Sinha and H.F. Tiersten
Dept. of Mech. Engrg., Aeronautical Engrg. & Mech., Rensselaer Polytechnic Inst., Troy, NY,
Wave Motion, 1 (1), pp 37-51 (1979) 4 figs, 20 refs

Key Words: Wave propagation, Elastic media

A system of linear electroelastic equations for small fields superposed on a bias is applied in the determination of the velocity of acoustic surface waves in piezoelectric substrates subject to flexural biasing stresses. The influence of the biasing stresses appears in the boundary conditions as well as the differential equations. Perturbation calculations are performed which include the influence of the spatial variation of all flexural biasing terms.

79-762
Frequency Dependence of Elastic (SH-) Wave Velocity and Attenuation in Anisotropic Two Phase Media

V.K. Varadan and V.V. Varadan
Dept. of Engrg. Mechanics, The Ohio State Univ., Columbus, OH,
Wave Motion, 1 (1), pp 53-63 (1979) 8 figs, 12 refs

Key Words: Wave propagation, Wave attenuation, Elastic media

The propagation and attenuation of elastic waves in a random anisotropic two-phase medium is studied using statistical averaging procedures and a self-consistent multiple scattering theory. The specific geometry and orientation of the inhomogeneities (second phase) are incorporated into the formulation via the scattering matrix of each inhomogeneity. At low frequencies, analytical expressions are derived for the effective wave number in the average medium as a function of the geometry and the material properties and the angle of orientation of the inclusions. The formulation is ideally suited for numerical computation at higher frequencies as evidenced by the results presented for composites reinforced by fibers of elliptical cross section.

79-763
On Energy Flux and Group Velocity

M. Hayes and M.J.P. Musgrave
Dept. of Mathematical Physics, University College Dublin, Dublin, UK,
Wave Motion, 1 (1), pp 75-82 (1979) 7 refs

Key Words: Wave propagation, Elastic media, Wave equation, Group velocity

Inhomogeneous plane wave solutions to the wave equations for a linear isotropic elastic solid and a linear isotropic dielectric are shown to possess energy flux velocity vectors which are non-coincident with corresponding group velocity vectors. In contrast to free surface waves, these examples imply a driving constraint and have an associated non-zero Lagrangian energy density.

79-764
Interface Separation Caused by a Plane Elastic Wave of Arbitrary Form

J. Dundurs and M. Comninou
Dept. of Civil Engrg., Northwestern Univ., Evanston, IL,
Wave Motion, 1 (1), pp 17-23 (1979) 4 figs, 7 refs

Key Words: Wave propagation, Elastic media

The paper considers the separation between two contacting solids caused by an incident elastic wave. The wave is assumed to be plane, but may have an arbitrary form. The unilateral interface between the solids is taken as frictionless and incapable of transmitting tension. If the disturbance propagates along the interface with a speed that is supersonic

with respect to both solids, the problem can be solved in closed form, and simple results for the extent of the separation zones and the respective gaps are obtained. Several specific examples are included.

79-765

One-Dimensional Deformation Waves in Nonlinear Viscoelastic Media

J. Engelbrecht

Inst. of Cybernetics, Lenin Ave. 10, 200104 Tallinn, Estonian SSR, USSR, Wave Motion, 1 (1), pp 65-74 (1979) 1 fig, 20 refs

Key Words: Wave propagation, Viscoelastic media, Constitutive equations

This paper is concerned with wave propagation processes in viscoelastic media. The constitutive equation is assumed to be dependent on the strain history, and physical and geometrical nonlinearities are taken into account. Using two equivalent forms of the constitutive equation, the corresponding transport equations are derived along the characteristics of a linear associated process. The high-frequency and low-frequency processes are investigated by making use of the asymptotic transport equations. The similarity of the results obtained by this method and by the singular surface theory is shown and the critical strain gradients derived by both methods are compared. The influence of inhomogeneity of the medium is discussed.

FATIGUE

79-766

Accumulation of Fatigue Damage Under Random Loading Conditions

J.T.D. Fritz

Strength Mechanics Div., National Mechanical Engrg. Research Inst., Pretoria, South Africa, Rept. No. CSIR-ME-1542, 46 pp (Dec 1977)
N78-32493

Key Words: Fatigue life, Random excitation

Some aspects of accumulation of fatigue damage under random loading conditions are presented and discrepancies between the linear cumulative damage law and actual in-service results are pointed out. Procedures for describing random loading spectra with descriptive parameters and counting methods are outlined and the possibility of utilizing the linear cumulative damage rule in conjunction with fatigue curves obtained with random loading spectra are presented and discussed.

FLUID

(Also see No. 731)

79-767

Energy Constraints in Vortex-Excited Vibrations

M.E. Greenway and C.J. Wood

Dept. of Engrg. Science, Univ. of Oxford, Oxford OX1 3PJ, UK, J. Sound Vib., 61 (2), pp 179-204 (Nov 22, 1978) 9 figs, 3 tables, 24 refs

Key Words: Fluid-induced excitation, Vortex-induced excitation

Excitation or damping of flow-induced vibrations depends upon the magnitude and the phase relationship between the fluid dynamic force and the oscillatory motion of the body. These are measured for two aerofoil shapes in mechanically controlled heaving motion in a water channel. Measurements are made of the strength and spacing of the associated vortex trails. An analysis based upon energy conservation has been performed. Comparing this analysis with the experimental data leads to a qualitative discussion of the significance of the vortex formation mechanism in controlling the excitation or damping of that class of vibrations which is affected by vortex shedding.

79-768

Technical Evaluation Report on the Fluid Dynamics Panel Symposium on Prediction of Aerodynamic Loading

R. Liaugminas

Wright-Patterson AFB, OH, Rept. No. AGARD-AR-125; ISBN-92-835-1296-0, 18 pp (Sept 1978)
N78-32074

Key Words: Aerodynamic loads, Fluid-induced excitation, Aircraft

The fluid dynamic aspects of predicting aerodynamic loads that represent difficult design and operating problems are examined with emphasis on theoretical and semi-empirical methods for determining the level and distribution of the expected loading and on assessing and evaluating the accuracy of the predicted values through comparison with available experimental data from wind tunnels and flight tests. Advances in the state-of-art of aerodynamic load prediction are summarized and problem areas for further research effort are indicated. Topics cover: test techniques; stores; high angle of attack; high lift and drag; viscous/inviscid interactions in transonic flow; maneuvering aircraft; unsteady loads on arbitrary bodies in supersonic flow; flow with separation; dynamic stall; buffeting; and special problem areas.

79-769

Time-Dependent Response of a Two-Dimensional Airfoil in Transonic Flow

D.P. Rizzetta

Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH 45433, AIAA J., 17 (1), pp 26-32 (Jan 1979) 10 figs, 23 refs

Key Words: Airfoils, Fluid-induced excitation, Aeroelasticity

A procedure is developed for the aeroelastic analysis of a two-dimensional airfoil in transonic flow. The fluid is assumed to be described by the unsteady low-frequency small-disturbance transonic potential equation for which a fully time-implicit integration scheme exists. Structural equations of motion are integrated in time simultaneously with the potential equation in order to predict the unsteady airfoil motion. As a computational example, a three-degree-of-freedom NACA 64A010 airfoil is considered using representative values of the structural parameters. The method is shown to be both stable and accurate, and the time response for several choices of initial conditions and reduced freestream density is presented.

79-770

Propagation of Nonlinear Acoustic Waves Induced by a Vibrating Cylinder. I. The Two-Dimensional Case

J.H. Ginsberg

School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Acoust. Soc. Amer., 64 (6), pp 1671-1678 (Dec 1978) 4 figs, 17 refs

Key Words: Sound waves, Wave propagation, Fluids, Vibrating structures

This study details the first successful uniformly valid expansion for a multidimensional nonlinear wave in a system described by curvilinear coordinates. The problem of the steady-state wave motion induced within an inviscid compressible fluid by an infinite circular cylinder executing a harmonic planar vibration in its nth circumferential mode is introduced. Examples considering the effect of the nondimensional parameters are treated by presenting pressure and velocity profiles, as well as nodal and antinodal lines of radial velocity. The range of validity for farfield approximations is discussed.

79-771

Propagation of Nonlinear Acoustic Waves Induced by a Vibrating Cylinder. II. The Three-Dimensional Case

J.H. Ginsberg

School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Acoust. Soc. Amer., 64 (6), pp 1679-1687 (Dec 1978) 4 figs, 12 refs

Key Words: Sound waves, Wave propagation, Fluids, Vibrating structures

The method derived in Part I for investigating the propagation of weakly nonlinear acoustic waves in systems described by curvilinear coordinates is extended herein to a three-dimensional situation. This is a determination of a uniformly valid first order approximation to the waves radiating from an infinitely long cylinder vibrating harmonically in a mode having circumferential wave number and axial wavelength.

SOIL

(Also see No. 732)

79-772

Resonant Column Test

V.P. Drnevich

Soil Dynamics Instruments, Inc., Lexington, KY, Rept. No. WES-MP-S-78-6, 82 pp (July 1978) AD-A058 902/8GA

Key Words: Soils, Vibratory techniques, Resonant bar technique

The resonant column test is used to determine by vibration the shear modulus, shear damping, rod modulus (Young's modulus) and rod damping of cylindrical specimens of soil in the undisturbed and remolded conditions. The vibration apparatus, apparatus calibration, and calculations are described. The reduction of all resonant column test data is presented in a computer program.

EXPERIMENTATION

DIAGNOSTICS

(Also see Nos. 780, 889)

79-773

Program for Field Validation of the Synthetic Aperture Focusing Technique for Ultrasonic Testing (SAFT UT); Analysis Before Test

J.L. Jackson

Southwest Research Inst., San Antonio, TX, Rept. No. NUREG-CR-0288, 50 pp (July 1978)

PB-286 857/8GA

Key Words: Diagnostic techniques, Ultrasonic techniques, Nondestructive tests

The purpose of the project is to validate the usefulness of SAFT UT for industrial nondestructive evaluations (NDE). SAFT UT is an ultrasonic imaging method for accurate measurement of the spatial location and extent of acoustically reflective surfaces (flaws) contained in objects such as structural components and weldments in nuclear power reactor systems. The increased measurement accuracy offered by SAFT, when compared with that provided by measurement methods now in use, will improve the reliability of flaw severity assessments with resultant safety and economic benefits to the nuclear power industry. To accomplish the objective, SwRI is to design and construct an imaging system, suitable for field use, using the SAFT UT and to conduct sufficient tests with the system to fully characterize its performance and usefulness for the intended purpose. The ultimate goal is to produce a field-rated system for highly accurate flaw size measurements and to conduct sufficient testing of that system to promote its acceptance by industrial and regulatory authorities.

79-774

Program for Field Validation of the Synthetic Aperture Focusing Technique for Ultrasonic Testing (SAFT UT)

J.L. Jackson

Southwest Research Inst., San Antonio, TX, Rept. No. NUREG-CR-0290, 52 pp (July 1978)

PB-287 317/2GA

Key Words: Diagnostic techniques, Ultrasonic techniques, Nondestructive tests

The purpose of the project is to validate the usefulness of SAFT UT for industrial nondestructive evaluations (NDE). SAFT UT is an ultrasonic imaging method for accurate measurement of the spatial location and extent of acoustically reflective surfaces (flaws) contained in objects such as structural components and weldments in nuclear power reactor systems. The increased measurement accuracy offered by SAFT, when compared with that provided by measurement methods now in use, will improve the reliability of flaw severity assessments with resultant safety and economic benefits to the nuclear power industry. To accomplish the objective, SwRI is to design and construct an imaging system, suitable for field use, using the SAFT UT and to conduct sufficient tests with the system to fully characterize its performance and usefulness for the intended purpose. The ultimate goal is to produce a field-rated system for highly accurate flaw size measurements and to conduct sufficient testing of that system to promote its acceptance by industrial and regulatory authorities.

79-775

Advanced Fault Detection and Isolation Methods for Aircraft Turbine Engines

R.L. DeHoff and W.E. Hall, Jr.

Systems Control, Inc., Palo Alto, CA, Rept. No. ONR-CR215-245-1, 99 pp (Feb 1, 1978)

AD-A058 891/3GA

Key Words: Diagnostic techniques, Computer-aided techniques, Aircraft engines, Turbofan engines

Aircraft engine diagnostic methods are reviewed. The role of computer-aided diagnostic procedures for current and future engines is discussed from the aspects of performance monitoring, trending, and fault detection/isolation. Development of advanced maximum likelihood or regression algorithms for each of these is presented. A methodology is developed for applying these algorithms to models derived from engine test stand or flight data. Specific computational results are given for a high performance turbofan engine.

79-776

Reliability of Machinery Using Fatigue Damage Accumulation Due to Random Vibrations

G.D. Xistris, T.S. Sankar, and G.L. Ostiguy

Concordia Univ., Montreal, Canada, J. Mech. Des., Trans. ASME, 100 (4), pp 619-625 (Oct 1978) 6 figs, 19 refs

Key Words: Machinery, Diagnostic techniques, Fatigue (materials), Random excitation

A new approach to machinery maintenance using fatigue damage accumulation theory is presented. The vibration generated by industrial equipment is related to the stress history experienced by the internal machine elements at the corresponding measurement points assuming a linear elastic and isotropic behavior. The resultant stress history is modeled as a piecewise stationary, Gaussian wide band process. Employing Miner's linear damage hypothesis in conjunction with available constant amplitude fatigue data, expressions for the expected accumulated fatigue damage and its variance are developed. A machinery maintenance program based on the accumulated damage parameters calculated directly from the properties of the exhibited vibration history is proposed. The main advantage of this method is that it provides equipment reliability in terms of known and measurable system properties.

79-777

Demodulated Resonance Analysis -- A Powerful Incipient Failure Detection Technique

D.R. Harting

Boeing Aerospace Co., ISA Trans., 17 (1), pp 35-40 (1978) 12 figs, 4 refs

Key Words: Diagnostic techniques, High frequency resonance technique, Machinery

A system which makes use of the high dynamic magnification present at the resonant frequencies of most piezoelectric transducers is discussed. The technique described is shown to produce incipient failure data.

79-778

On-Line Machinery Measurement and Recording System

H.R. Hegner and N.F. Muelleman

GARD, Inc., ISA Trans., 17 (1), pp 41-47 (1978) 5 figs, 3 tables

Key Words: Diagnostic instrumentation, Machinery

This paper discusses the problems associated with the development of a universal on-machine instrumentation system for laboratory, shipboard, and power station applications. A small and rugged microprocessor-based system is described which can be easily attached to the machinery under test and operated unattended for long periods in either a laboratory or field environment.

79-779

Acoustic Monitoring Instrumentation for Pressurized Water Reactors

R. Gopal, J.R. Smith, and G.V. Rao

Westinghouse Nuclear Energy Systems, ISA Trans., 17 (3), pp 71-80 (1978) 15 figs, 2 refs

Key Words: Diagnostic instrumentation, Nuclear power plants, Acoustic techniques

In this article special instrumentation considerations for nuclear plants are discussed, the principles of acoustic emission and leak monitoring are reviewed, and a prototype acoustic monitoring system is described. A large measure of work is currently directed toward learning to interpret the detected signals. Results of recent shop, plant, and laboratory examinations are presented.

INSTRUMENTATION

(Also see Nos. 778, 779)

79-780

Hybrid Holographic Non-Destructive Test System

R.L. Kurtz

Marshall Space Flight Center, NASA, Huntsville, AL, US-Patent-4,093,382, 9 pp (June 6, 1978) N78-32447

Key Words: Nondestructive tests, Holographic techniques, Testing techniques, Test instrumentation

An automatic hybrid holographic non-destructive testing (HNDT) method and system capable of detecting flaws or debonds contained within certain materials are described. This system incorporates the techniques of optical holography, acoustical/optical holography and holographic correlation in determining the structural integrity of a test object. An automatic processing system including a detector and automatic data processor is used in conjunction with the three holographic techniques for correlating and interpreting the information supplied by the non-destructive systems. The automatic system also includes a sensor which directly translates an optical data format produced by the holographic techniques into electrical signals and then transmits this information to a digital computer for indicating the structural properties of the test object. The computer interprets the data gathered and determines whether further testing is necessary as well as the format of this new testing procedure.

TECHNIQUES

(Also see Nos. 772, 780)

79-781

Impedance Measurement Using a Two-Microphone, Random-Excitation Method

A.F. Seybert

Langley Res. Center, NASA, Hampton, VA, Rept. No. NASA-TM-78785, 40 pp (Oct 1978)
N78-33875

Key Words: Acoustic impedance, Measurement techniques, Random excitation

The feasibility of using a two-microphone, random-excitation technique for the measurement of acoustic impedance is studied. Equations are developed, including the effect of mean flow, which show that acoustic impedance is related to the pressure ratio and phase difference between two points in a duct carrying plane waves only. The impedances of a honeycomb ceramic specimen and a Helmholtz resonator are measured and compared with impedances obtained using the conventional standing-wave method. Agreement between the two methods is generally good. A sensitivity analysis is performed to pinpoint possible error sources and recommendations were made for future study.

79-782

A Research Program to Reduce Interior Noise in General Aviation Airplanes: Investigation of the Characteristics of an Acoustic Panel Test Facility

F. Grosveld and J. vanAken

Center for Research, Inc., Kansas Univ., Lawrence, KS, Rept. No. NSAS-CR-157587, 151 pp (Sept 1978)
N78-31874

Key Words: Measurement techniques, Interior noise, Aircraft noise

Sound pressure levels in the test facility are studied that are caused by varying microphone positions; equalizer setting; and panel clamping forces. Measurements are done by using a Beranek tube or this Beranek tube in combinations with an extension tube and a special test section. The influence of the speaker back panel and the back panel of the Beranek tube on the sound pressure levels inside the test tube are also investigated.

COMPONENTS

SHAFTS

79-783

Bounds to Frequencies of Shafts in Torsional Vibration with Restraints and Attached Masses

N. Rubinstein, V.G. Sigillito, and J.T. Stadter

Appl. Physics Lab., The Johns Hopkins Univ., Laurel, MD 20810, J. Sound Vib., 61 (1), pp 31-44 (Nov 8, 1978) 4 figs, 5 tables, 15 refs

Key Words: Mass-beam systems, Shafts, Torsional vibration, Boundary value problems, Eigenvalue problems

In this paper upper and lower bounds are given to eigenvalues of torsional vibration of the following uniform structures: free shaft elastically restrained at a point; fixed shaft elastically restrained at a point; free shaft with masses elastically attached at points, and fixed shaft with a mass elastically attached over an interval. Upper bounds are obtained by using the well-known Rayleigh-Ritz procedure. The various problems discussed in this paper illustrate the use of these lower bound methods and their effectiveness in producing excellent bounds.

BEAMS, STRINGS, RODS, BARS

79-784

An Experimental Study of First-Passage Failure of a Randomly Excited Structure

J.B. Roberts and S.N. Yousri

School of Engrg. and Appl. Sciences, The Univ. of Sussex, Falmer, Brighton, Sussex BN1 9QT, UK, J. Appl. Mech., Trans. ASME, 45 (4), pp 917-922 (Dec 1978) 8 figs, 11 refs

Key Words: Cantilever beams, Failure analysis, Random excitation, Damping effects, Experimental data

Some experimental measurements of the mean and standard deviation of the first-passage time of randomly excited cantilevers are presented. It is shown that these results can be predicted by using a theoretical method based on the energy envelope of the structure, together with information on the energy loss per cycle. This information can be derived either from free decay tests or from data on specific damping factors. Some predicted nonlinear effects are confirmed by the experimental results.

79-785

Nonlinear Material Damping for Nonsinusoidal Strain

R. Plunkett and M. Sax

Dept. of Aerospace Engrg. and Mechanics, Univ. of Minnesota, Minneapolis, MN 55455, J. Appl. Mech., Trans. ASME, 45 (4), pp 883-888 (Dec 1978) 11 figs, 11 refs

Key Words: Cantilever beams, Material damping, Resonant frequencies

The damping in uniform and nonuniform cantilever beams is measured at resonance for a range of amplitudes of simultaneous steady-state first and second mode vibration. For two linear materials, aluminum and crossply fiberglas, the damping factor in each mode is independent of amplitude and unaffected by the presence of the other mode. For a fully annealed tool steel with highly nonlinear damping, the damping factor in each mode is markedly increased by the presence of the other mode.

79-786

On the Vibration and Stability of a Free-Free Beam Subjected to End-Loads

Z. Celep

Faculty of Engrg. and Architecture, Technical Univ., Istanbul, Turkey, J. Sound Vib., 61 (3), pp 375-381 (Dec 8, 1978) 3 figs, 15 refs

Key Words: Beams, Axial force, Stability

In this paper the vibration and stability of a free-free beam subjected to direction-controlled axial loads at its ends are investigated. The eigencurves and mode shapes of the beam are presented for various values of the directional control parameter.

79-787

The Transverse Vibratory Response of Partially Constrained Elastic-Viscoelastic-Elastic Beams

B.E. Douglas

Ph.D. Thesis, Univ. of Maryland, 154 pp (1978) UM 7824010

Key Words: Beams, Layered materials, Flexural vibration, Damping effects

The dynamic effects of compressional and shear damping in the vibratory response of both fully constrained and partially constrained elastic-viscoelastic-elastic beams are investigated in a mechanical impedance format. Equations of transverse motion are derived for the fully constrained and partially constrained compressionally damped three-layer laminate and solved using progressive wave methods where complex wave numbers are obtained. The shear damping model developed by Mead and Markus is reformulated for the fully constrained case in a progressive wave format and then extended for partial constraining layer coverage where appropriate boundary conditions are derived. These models are evaluated through comparison to several experiments and, for the case of compressional damping, through the comparison with the dynamic response of the distributed mass-spring-mass system.

79-788

Non-Linear Vibrations of Three-Layer Beams with Viscoelastic Cores. II: Experiment

M.W. Hyer, W.J. Anderson, and R.A. Scott

Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 61 (1), pp 25-30 (Nov 8, 1978) 5 figs, 4 refs

Key Words: Beams, Viscoelastic core-containing media, Damped structures, Layered damping, Forced vibration, Experimental data

Experimental results are presented for large amplitude, forced motion of damped, three-layer beams. The beams are constructed with a viscoelastic material constrained between stiff, elastic, outer layers. The sandwich beam is axially restrained. Frequency response characteristics, spatial shapes and a measure of superharmonic response are presented.

79-789

Reference Frequencies for the Validation of Numerical Solutions of Transverse Vibrations of Non-Uniform Beams

B. Downs
Dept. of Mech. Engrg., Loughborough Univ. of Tech., Loughborough LE11 3TU, UK, J. Sound Vib., 61 (1), pp 71-78 (Nov 8, 1978) 7 tables, 25 refs

Key Words: Beams, Variable cross section, Flexural vibration

Tables of natural frequencies, calculated from exact analytical solutions are presented for beams of various geometries including truncated tapered cantilevers and pre-twisted uniform beams. Independent numerical solutions are used in several instances to confirm the accuracy.

79-790

Frequencies and Loss Factors of Multicored Sandwich Beams

D.K. Rao
Institut f. Mechanischeschwingungslehre und Machinen Dynamik, Technische Universität Berlin, Berlin, West Germany, J. Mech. Des., Trans. ASME, 100 (4), pp 667-674 (Oct 1978) 8 figs, 18 refs

Key Words: Beams, Sandwich structures, Viscoelastic damping

The sandwich beam analyzed in the present paper consists of layers of elastic and viscoelastic material of arbitrary thickness and material. High-order effects such as rotatory inertia, bending, and extension of the core are included in the equations of motion presented. Exact equations for finding resonant frequencies and loss factors are given for simply-supported beams, while for other boundary conditions, these quantities are computed by variational methods.

79-791

Mono-Coupled Periodic Systems with a Single Disorder: Response to Convected Loadings

D.J. Mead and A.S. Bansal
Dept. of Aeronautics and Astronautics, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 61 (4), pp 497-515 (Dec 22, 1978) 8 figs, 17 refs

Key Words: Beams, Forced vibration, Periodic structures

This paper presents a general theory of the forced response under convected loading of mono-coupled periodic systems with a single disorder. The general expressions derived are used to study the response of an infinite periodic beam on simple supports with one of the support spacings different from all the others. Convected harmonic pressure fields and frozen random pressure fields are considered. Computer studies are presented showing the moment response at supports and the space-time-averaged responses in the disorder and in the nearby periodic beam elements. The dependence of the maximum response levels on the magnitude of the disorder is investigated. The conditions under which small disorders may be neglected are pointed out.

79-792

Vibration Frequency of a Curved Beam with Tip Mass

S.V. Hoa
Dept. of Mech. Engrg., Concordia Univ., Montreal, Canada, J. Sound Vib., 61 (3), pp 427-436 (Dec 8, 1978) 6 figs, 1 table, 6 refs

Key Words: Curved beams, Mass-beam systems, Fan blades, Geometric effects, Vibration frequencies, Finite element technique

This paper reports on an investigation of the vibration frequency of a curved beam with a tip mass, in which both theoretical finite element and experimental methods are used. In the finite element methods, both the normal and tangential displacements are approximated by cubic polynomials. The effect of the tip mass is incorporated into the mass matrix.

79-793

Mono-Coupled Periodic Systems with a Single Disorder: Free Wave Propagation

D.J. Mead and A.S. Bansal
Dept. of Aeronautics and Astronautics, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 61 (4), pp 481-496 (Dec 22, 1978) 11 figs, 7 refs

Key Words: Beams, Periodic structures, Mass-beam systems, Mass-spring systems

A general method is presented for analyzing free harmonic wave propagation through a mono-coupled periodic system with a single disorder. Expressions are derived for the magnitudes of the waves transmitted and reflected by the disorder. These general expressions are used to study flexural wave motion through a periodic beam system into which three different types of disorder have been introduced: a beam element of non-periodic length; a rotary mass at a support; and a rotary spring at a support. Conditions are identified under which the combined disorder plus periodic system can behave like a resonating spring-mass-system, or as a spring-mass damper system. Qualitative and quantitative analysis based upon computer studies indicate how disorders can be used most effectively for vibration isolation in existing periodic systems or when designing new systems.

79-794

Natural Frequencies of Curved Elastic Arcs

N.J. Kudva, A.H. Nayfeh, and M.P. Kamat

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Acoust. Soc. Amer., 64 (6), pp 1700-1702 (Dec 1978) 2 figs, 2 tables, 5 refs

Key Words: Curved beams, Natural frequencies, Perturbation theory

A perturbation analysis is presented for calculating the inextensional natural frequencies of curved elastic arcs. Variation of the radius of curvature along the arc length is accounted for by considering the curvature to be a perturbation from a constant curvature, and utilizing the method of strained parameters. Frequencies thus derived for hinged parabolic arcs demonstrate good agreement with finite element solutions.

79-795

Generalized Orthogonality Relation for Rectangular Strips in Elastodynamics

B.G. Prakash

Structural Analysis Group, Mechanical Systems Div., Indian Space Res. Organisation Satellite Centre, Bangalore 560 058, India, Mech. Res. Comm., 5 (5), pp 251-255 (1978) 4 refs

Key Words: Rectangular bars, Wave propagation, Elastic waves, Boundary value problems

The aim of this paper is to present general orthogonality relations for the modes of wave propagation in rectangular strips. The long edges of the strip are subjected to any admissible combination of homogeneous boundary conditions. Generalized orthogonality relations of similar types for problems associated with curved beams and sectors in plane elastostatics are presented. These relations are compact and can be used to obtain solutions of various problems.

BEARINGS

(Also see Nos. 726, 877)

79-796

Control of Clearance Effects in Mechanisms

S.J. Grant and J.N. Fawcett

International Research and Development Co., Ltd., Newcastle upon Tyne, UK, J. Mech. Des., Trans. ASME, 100 (4), pp 728-731 (Oct 1978) 6 figs, 9 refs

Key Words: Clearance effects, Mechanisms, Bearings

A method for preventing contact loss in a bearing by the use of constant magnitude spring forces, arranged so that the maximum bearing load is not increased, is described. Experimental results from a four bar linkage are presented. A method for calculating the magnitude of the required spring force using a standard no-clearance analysis is described.

BLADES

79-797

Design and Development of a System to Measure the Mode Shapes of a Vibrating, Rotating Helicopter Blade in a Vacuum

F.J. Fronczak

Ph.D. Thesis, Univ. of Kansas, 423 pp (1978)

UM 7824860

Key Words: Helicopter rotors, Rotor blades (rotary wings), Mode shapes, Measurement techniques, Photographic techniques, Measuring instruments

A photographic technique and equipment used to measure the mode shapes of a vibrating, rotating helicopter blade are described. Two camera systems are described. One uses cylindrical lenses and a baffling arrangement to take photographs of a line on an object. The other camera uses conventional spherical lenses to photograph the rotor blade. These photographs provide data which is reduced to yield the components of vibration of a full size rotating helicopter blade vibrating at resonance. The rotor test stand, which rotates and excites the blade vibration is described in detail. Blade deflection data is tabulated and plotted for several rotational speeds and frequencies.

79-798

Preliminary Design Study of a Tail Rotor Blade Jettison Concept

R.A. Selleck

Sikorsky Aircraft Div., United Technologies Corp., Stratford, CT, Rept. No. SER-70280, USARTL-TR-78-28, 267 pp (July 1978)

AD-A059 239/4GA

Key Words: Rotary wings, Blade loss dynamics, Helicopter rotors

Using the performance characteristics of the UH-60A BLACK HAWK helicopter, a prototype system is developed and its performance evaluation used to determine the capability of the system to jettison rotor blades in a manner that would prevent secondary damage. Analyses are conducted to determine the dynamic stability characteristics of the UH-60A tail rotor in a two-bladed configuration and the ability of the helicopter to accommodate the loads developed during transition from four to two blades. Residual helicopter performance and the capability of the helicopter to be retrimmed following jettison of two opposing tail rotor blades is analyzed using the General Helicopter Flight Dynamic Model programmed on a PDP-10 Hybrid Computer.

79-799

Blade Row Dynamic Digital Compression Program. Volume 2: J85 Circumferential Distortion Redistribution Model, Effect of Stator Characteristics and Stage Characteristics Sensitivity Study

W.A. Tesch and W.G. Steenken

Aircraft Engine Group, General Electric Co., Cincinnati, OH, Rept. No. NASA-CR-134953, 76 pp (July 1978)

N78-33103

Key Words: Compressor blades, Dynamic response, Computer programs

The results of dynamic digital blade row compressor model studies of a J85-13 engine are reported. The calculation of the circumferential redistribution effects in the blade-free volumes forward and aft of the compression component is covered. Identifying the rotor dynamic response to spatial circumferential distortions is analyzed. Inclusion of the rotor dynamic response leads to a considerable gain in the ability of the model to match the test data. The impact of variable stator loss on the prediction of the stability limit is evaluated. An assessment of measurement error on the derivation of the stage characteristics and predicted stability limit of the compressor is also performed.

79-800

Dynamic Response of Packets of Blades by the Finite Element Method

A.L. Salama and M. Petyt

Arab Maritime Transport Academy, Alexandria, ARE, J. Mech. Des., Trans. ASME, 100 (4), pp 660-666 (Oct 1978) 11 figs, 11 refs

Key Words: Turbine blades, Free vibration, Finite element technique, Harmonic excitation

The finite element method is used to study the free vibration of packets of blades. A packet of six shrouded blades is analyzed, only the tangential vibrations being considered. Results are obtained to establish the effect of certain parameters such as stiffness ratio, mass ratio, the number of blades in the packet, the effect of rotation and the position of the lacing wires. The dynamic response of a packet to periodic loading is also studied. The cases of engine order harmonic excitation and partial admission of gas are considered with reference to a packet of six shrouded blades.

79-801

Finite Element Dynamic Analysis of Practical Discs

C.A. Mota Soares and M. Petyt

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 61 (4), pp 547-560 (Dec 22, 1978) 4 figs, 28 refs

Key Words: Discs, Turbine components, Finite element technique, Natural frequencies

A semi-analytical annular finite element is developed for the dynamic analysis of non-rotating, rotating or pre-stressed discs having varying thickness in the radial direction. The element is based on the Mindlin thick plate theory. The element is applied to the dynamic analysis of non-rotating and rotating uniform discs, and to practical turbine discs. The predicted natural frequencies of the discs are compared with analytical, experimental and other finite element solutions.

79-802

Finite Element Dynamic Analysis of Practical Bladed Discs

C.A. Mota Soares and M. Petyt

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 61 (4), pp 561-570 (Dec 22, 1978) 10 figs, 6 tables, 8 refs

Key Words: Turbomachinery blades, Turbine blades, Turbine components, Discs, Finite element technique

The dynamic characteristics of one blade, two discs and one shrouded, bladed disc, having 87 blades, are predicted by the application of the finite element method of analysis. The discs are modeled by using both annular and sector elements. The blades are modeled by means of shell elements. The shrouds are represented by both lumped masses and straight beam elements. The predicted frequencies are compared with experimental results.

COLUMNS

79-803

Nonlinear Analysis of the Lateral Response of Columns to Periodic Loads

E.G. Tezak, D.T. Mook, and A.H. Nayfeh

Dept. of Mechanics, U.S. Military Academy, West Point, NY 10996, J. Mech. Des., Trans. ASME, 100 (4), pp 651-659 (Oct 1978) 9 figs, 4 refs

Key Words: Columns (supports), Parametric excitation, Periodic excitation

Parametrically excited transverse oscillations of columns are studied. The amplitude of the response is taken to be small, but finite; hence, stretching of the neutral axis is significant. Nonlinear strain-displacement relationships are used. A general method of analysis is first described and then used to solve two numerical examples -- one without and one with internal resonances.

CONTROLS

79-804

Isolation and Relief Valve/Piping Transient Forces

C.R. Pignoli

Nuclear Services Corp., ISA Trans., 17 (3), pp 45-51 (1978) 13 figs, 4 refs

Key Words: Valves, Piping systems, Nuclear power plants, Nuclear reactor components, Transient response, Computer programs

The operation and analytical techniques used to define the loading conditions on such valves as the main stream isolation, check and relief, are discussed. A computer program which was developed to analyze the transient forces on the valves and piping is also presented.

79-805

On the Nonlinear Response of a Relief Valve

M.A. Dokainish and M.M. Elmadany

Dept. of Mech. Engrg., McMaster Univ., Hamilton, Ontario, Canada, J. Mech. Des., Trans. ASME, 100 (4), pp 675-680 (Oct 1978) 10 figs, 9 refs

Key Words: Valves, Free vibration, Forced vibration

The free and forced response of a relief valve system is analyzed. The valve system consists of a valve having a mass, resting on a seat having nonlinear spring characteristics, and retained by a helical spring which is considered to be a distributed parameter element. The response curves of the first and third harmonic and one-third subharmonic, the amplitudes of which vary with the frequency of the external force, are investigated and presented graphically. Jump and hysteresis phenomena analogous to that of nonlinear single-degree-of-freedom systems are observed.

79-806

Control Valve Noise Prediction

C.L. Reed

Masoneilan International, Inc., Norwood, MA, S/V, Sound Vib., 12 (11), pp 20-22 (Nov 1978) 2 figs, 1 table, 10 refs

Key Words: Valves, Control equipment, Noise prediction

Based on an extensive laboratory study, improvements have been made in the noise prediction state of the art. These improvements incorporate new pipe transmission loss theory as well as refinement in the valve noise generation model as related to control valves. Test data has been compiled for all styles of control valves and compared to the new prediction model with improved agreement over first generation methods.

79-807

Noise Created by Control Valves in Compressible Service

C.L. Reed

Masoneilan International, Inc., ISA Trans., 17 (1), pp 105-109 (1978) 1 fig, 1 table, 10 refs

Key Words: Control valves, Noise reduction, Industrial noise, Mathematical models

Control valves are a major factor in the industrial acoustic environment. To properly and efficiently engineer this potential noise source for the minimum cost/benefit, an understanding of noise generation during the throttling process is required. A mathematical model is developed for use on any compressible service with any generalized valve style (globe, butterfly, ball, etc). This model is substantiated with data samples from both laboratory and field tests on various compressible media.

DUCTS

79-808

Low Frequency Acoustic Transmission Through the Walls of Rectangular Ducts

A. Cummings

Inst. of Environmental Science and Tech., Polytechnic of the South Bank, London SE1 0AA, UK, J. Sound Vib., 61 (3), pp 327-345 (Dec 8, 1978) 13 figs, 8 refs

Key Words: Ducts, Walls, Sound transmission, Air conditioning equipment

A simple theory is described for the transmission of low frequency sound through the walls of rectangular ducts, particularly those in air conditioning systems. The model is based on a coupled acoustic/structural wave system, and it is assumed that the duct radiates in the same way as a finite-length line source incorporating a single traveling wave. Measurements of wall transmission loss on two types of duct system are compared to theoretical predictions, and good agreement is obtained within the frequency range of validity of the theory.

79-809

The Attenuation of Lined Plenum Chambers in Ducts: I. Theoretical Models

A. Cummings

Inst. of Environmental Science and Tech., Polytechnic of the South Bank, London SE1 0AA, UK, J. Sound Vib., 61 (3), pp 347-373 (Dec 8, 1978) 14 figs, 8 refs

Key Words: Ducts, Linings, Sound transmission loss

Two types of theory are described, with the purpose of predicting the acoustic transmission loss of lined plenum chambers which are sometimes used as attenuators in air conditioning duct systems. The first kind of theory embodies a low frequency wave acoustic approach, and two separate models are evolved: one is for a single plenum chamber, and the second is for a plenum chamber incorporating one or more acoustically lined baffles. The other type of theory is valid at high frequencies, and is based upon geometrical, or ray, acoustics. This is applied to a single chamber and to chambers containing either one or two lined baffles. Both the high frequency and low frequency results are reasonably simple.

GEARS

(Also see No. 877)

79-810

The Rigidity and Performance of a Helicopter Gearbox with a Cantilevered Housing and Two Taper Roller Bearings

M.M.A. Taha, C.M.M. Ettles, and P.B. MacPherson

Dept. of Mech. Engrg., Imperial College, London, UK, J. Mech. Des., Trans. ASME, 100 (4), pp 696-702 (Oct 1978) 7 figs, 2 tables, 4 refs

Key Words: Gear boxes, Helicopters, Structural members, Cantilever beams, Computer programs

A theoretical study has been made to determine the rigidity and performance of a helicopter gearbox with a cantilevered housing and two taper roller bearings. Due to the interaction of the deflection of all component parts such as gears, shafts, bearings, casings, spacers, etc., it is necessary to consider these in combination. A computer program is developed for analyzing a typical helicopter type input pinion assembly in which the pinion is supported by a pair of taper roller bearings. This program is suitable for determining the influence that various factors exert on the rigidity of the pinion and the performance of the bearings. The influence of endfloat or preload, misalignment of the races, casing and shaft deflection, wall thickness of the casing and the hollow shaft, and the spacing between bearings are considered.

79-811

Gear Mesh Excitation Spectra for Arbitrary Tooth Spacing Errors, Load and Design Contact Ratio

E.P. Remmers

Engrg. Mechanics Dept., General Motors Res. Labs., Warren, MI, J. Mech. Des., Trans. ASME, 100 (4), pp 715-722 (Oct 1978) 16 figs, 16 refs

Key Words: Gears, Gear noise, Geometric effects, Vibration excitation

This paper describes an analytical method for assessing the influence of factors such as tooth spacing errors, load, design contact ratio, and profile modifications on the excitation force at the gear mesh for gears with a form of profile modification which gives zero excitation at design load in the absence of spacing errors.

LINKAGES

79-812

The Analytical and Experimental Evaluation of Vibratory Oscillations in Realistically Proportioned Mechanisms

J.R. Sanders and D. Tesar

Milliken Research Corp., Spartanburg, SC, J. Mech. Des., Trans. ASME, 100 (4), pp 762-768 (Oct 1978) 12 figs, 1 table, 18 refs

Key Words: Mechanisms, Linkages, Flexural vibration, Inertial forces

Deformations in mechanisms composed of link members of realistic proportions and commonly used materials are studied both analytically and experimentally. A four-bar linkage coupler link of five distinct bending rates is strain gauge tested to confirm results predicted by a decoupled vibration study of the same link.

79-813

The Small Motion Dynamics of Bilaterally Coupled Kinematic Chains with Flexible Links

W.G. Beazley

Ph.D. Thesis, The Univ. of Texas at Austin, 185 pp (1978)
UM 7900533

Key Words: Chains, Linkages, Computerized simulation

A procedure for simulating mechanisms with both lower and higher order kinematic pairs and flexible links in a three dimensional configuration is developed by extending the method of transfer matrices to include such devices. The machine is divided into two parts. One consists of a lower pair chain containing only lower order pairs and associated links. The other part is the remainder, termed a coupling between the links of the chain. The coupling is bilateral and the Denavit-Hartenberg coordinate algorithm is used. The dynamic properties of the bilateral coupling are included by separate operations on the extracted variables.

79-814

A Dynamic Analysis of Mechanisms with Clearances

H. Funabashi, K. Ogawa, and M. Horie

Tokyo Inst. of Tech., Ookayama, Meguro-ku, Tokyo, Japan, Bull. JSME, 21 (161), pp 1652-1659 (Nov 1978) 12 figs, 1 table, 10 refs

Key Words: Mechanisms, Linkages, Equations of motion

The equations of motion of arbitrary moving links and the constraint equations of pairs are derived with consideration of the elastic deformations of pairing elements and frictions, which make it possible to construct systematically the equations of motion of plane multilink mechanisms with clearances. The dynamic characteristics of a slider-crank mechanism with a clearance are theoretically and experimentally analyzed, revealing the influences of the clearance and the crank speed upon the relative motions between the pairing elements, input torque, and output displacement.

PANELS

79-815

Dynamic Behaviour of a Simply Supported Circular Cylindrical Panel Subjected to an Initial Bending Moment

C. Massalas and K. Soldatos

Dept. of Mechanics, Univ. of Ioannina, Ioannina, Greece, J. Sound Vib., 61 (1), pp 61-69 (Nov 8, 1978) 2 figs, 3 tables, 9 refs

Key Words: Panels, Cylinders, Circular panels

The vibration of cylindrical panels with simply supported boundary conditions in the presence of an initial bending moment is investigated. The analysis is based on the theory of Herrmann and Armenàkas. The results for the stability and free vibration of the panels are obtained as special cases.

PIPES AND TUBES

(Also see Nos. 751, 804)

79-816

Strength and Dynamic Characteristics of Gasket-Jointed Concrete Water Pipelines

R.G. Kratky and M.G. Salvadori

Weidlinger Associates, NY, Rept. No. NSF/RA-780225, 291 pp (June 1978)

PB-285 728/2GA

Key Words: Pipelines, Water pipelines, Prestressed concrete, Underground structures, Joints (junctions), Failure analysis, Seismic excitation

This study extends to gasket-jointed concrete water-pipelines the information given in previous reports on cast-iron pipelines. Types of concrete pipe and their usage are included; prestressed concrete cylinder pipe and prestressed concrete embedded cylinder pipe are discussed in detail. A description of the actual performance of some existing concrete pipelines including dates of installation and types of failure, is included. Some test data on pipes and joints are considered. The general design methods used by the manufacturing industry are illustrated by means of examples. A brief review of the recommendations on pipe design by the Bureau of Reclamation and the American Water Works Association is given.

79-817

Strength and Dynamic Characteristics of Mechanically Jointed Cast-Iron Water Pipelines

R.G. Kratky and M.G. Salvadori

Weidlinger Associates, NY, Rept. No. NSF/RA-780224, 48 pp (June 1978)

PB-285 727/4GA

Key Words: Pipelines, Water pipelines, Joints (junctions), Failure analysis, Seismic excitation

Elastic and dynamic characteristics of both mechanical joints with rubber gaskets and cast-iron pipes are discussed. The main characteristics for pipe failure are the ultimate tension force and the ultimate bending moment. Bolt failure, ultimate gasket friction, the longitudinal elastic constant of gasket, longitudinal periods of pipe due to gasket elasticity, longitudinal periods of pipe due to pipe elasticity, the rotational constant of gasket, periods of rotational motion due to gasket, and periods of vibration for vertical anti-symmetrical rotational modes of continuous elastic pipes are discussed.

PLATES AND SHELLS

(Also see No. 729)

79-818

Large Amplitude Axisymmetric Vibrations of Annular Plates with Edges Elastically Restrained Against Rotation

G.V. Rao and K.K. Raju

Structural Engrg. Div., Vikram Sarabhai Space Centre, Trivandrum-695022, India, Computers Struc., 9 (6), pp 609-613 (Dec 1978) 5 tables, 6 refs

Key Words: Plates, Axisymmetric vibrations, Boundary condition effects

Large amplitude axisymmetric vibrations of annular plates with the inner and outer edges elastically restrained against rotation, are considered in this paper. A finite element formulation is used to obtain the effect of elastical restraints on the nonlinear to linear period ratios of annular plates of different radii ratios.

79-819

Dynamic Response of Inelastic Thick Plates

S.S. Rao and K.S. Raghavan

Indian Inst. of Tech., Kanpur, India, AIAA J., 17 (1), pp 85-90 (Jan 1979) 8 figs, 18 refs

Key Words: Plates, Dynamic response, Finite element technique, Transverse shear deformation effects

The dynamic behavior of inelastic thick plates is investigated. A 36-degree-of-freedom rectangular finite element, which includes shear deformation effects and adequately represents associated boundary conditions, is developed. The accuracy of the element is established through comparison with available results for static deflection and natural frequencies. The yield surface is considered as a function of in-plane and transverse shear stresses. It is found that the contribution of the transverse shear stresses upon the plastic deformations is relatively small. The response of simply supported and clamped thick plates to impulse excitation is found and the results are compared with those obtained from thin plate theory.

79-820
An Approximate Theory for the Sound Radiated from a Periodic Line-Supported Plate
D.J. Mead and A.K. Mallik
Dept. of Aeronautics and Astronautics, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 61 (3), pp 315-326 (Dec 8, 1978) 4 figs, 1 table, 5 refs

Key Words: Plates, Sound pressures, Energy methods

An approximate method is presented for estimating the sound power radiated by an infinite plate, supported elastically along parallel, equi-spaced lines and subjected to a simple pressure field convecting uniformly over the plate in a direction perpendicular to the supports. Suitable complex modes are assumed for the induced plate flexural wave motion, and an energy method is used to estimate the plate response and the radiated sound power. The influence of the convection velocity and of certain plate parameters is investigated.

79-821
Free Vibration of Cross-Shaped, I-Shaped and L-Shaped Plates Clamped at all Edges
T. Irie, G. Yamada, and Y. Narita
Dept. of Mech. Engrg., Hokkaido Univ., Sapporo 060, Japan, J. Sound Vib., 61 (4), pp 571-583 (Dec 22, 1978) 7 figs, 13 refs

Key Words: Plates, Geometric effects, Natural frequencies, Mode shapes, Eigenvalue problems

This paper presents a new series-type method for solving the eigenvalue problems of irregularly shaped plates clamped at all edges. An irregularly shaped plate is formed on a simply supported rectangular plate by rigidly fixing several segments. With the reaction forces and moments acting on all edges of an actual plate or irregular shape regarded as unknown harmonic loads, the stationary response of the plate to these loads is expressed by the use of the Green function. The force and moment distributions along the edges are expanded into Fourier series with unknown coefficients, and the homogeneous equations for the coefficients are derived by restraint conditions on the edges. The natural frequencies and the mode shapes of the actual plate are determined. The method is applied to a cross-shaped, an I-shaped and an L-shaped plate clamped at all edges, the natural frequencies and the mode shapes of the plates are calculated numerically and the effect of the shape is discussed.

79-822
Resonance Phenomena in the Nonlinear Vibration of Plates Governed by Duffing's Equation
W.J. Parzygnat and Y. Pao
Xerox Corp., Rochester, NY 14644, Intl. J. Engr. Sci., 16 (12), pp 999-1017 (1978) 15 figs, 18 refs

Key Words: Plates, Nonlinear systems, Vibration resonance

This paper presents a theoretical and experimental study of the resonance phenomena of a nonlinear system, the time dependent part of which is governed by Duffing's equation. The method of Krylov, Bogoliubov and Mitropolsky is applied to analyze the transient motion near resonance. Experimental results are presented for a clamped circular plate driven into large amplitude oscillations by a magnetic force, during the downward and upward jumps. The transient nonlinear response curves during the jumps, and the free vibration (skeleton) curves of the plate are determined experimentally. Methods for measuring the damping coefficient, linear frequency and nonlinear stiffness of the plate are also discussed.

79-823
Free Vibration of Circular Plate Elastically Supported at Some Points
T. Irie and G. Yamada
Faculty of Engrg., Hokkaido Univ., Sapporo, Japan, Bull. JSME, 21 (161), pp 1602-1609 (Nov 1978) 7 figs, 7 tables, 6 refs

Key Words: Circular plates, Harmonic excitation, Natural frequencies, Mode shapes

This paper studies the free vibration of a circular plate whose deflection, rotation and torsion are elastically supported at some points located inside the plate or on the circumference. Regarding the reactive forces and moments at all points as unknown harmonic exciting loads, the stationary response of the plate to these loads is derived. The natural frequencies and the mode shapes of the plate are calculated

by determining the unknown quantities with use of constraint conditions at the supports. Applying the method to a circular plate supported at some equi-spaced points of equal radii, the natural frequencies and the mode shapes are calculated numerically.

79-824

Axisymmetric Vibrations of Orthotropic Composite Circular Plates

J.B. Greenberg and Y. Stavsky
Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Sound Vib., 61 (4), pp 531-545 (Dec 22, 1978) 8 figs, 8 refs

Key Words: Composite materials, Circular plates, Axisymmetric vibrations, Equations of motion

A sixth order system of equations of motion is formulated in terms of the radial and transverse displacements for axisymmetric vibrations of circular plates laminated of polar orthotropic plies. Previous results for heterogeneous isotropic circular plates are included as a special case in the present theory. The eigenvalue problem is solved numerically, by using a finite difference method, and results are presented for various two and triple layer composites.

79-825

Wide-Band Random Vibration of Circular Plates

K. Itao and S.H. Crandall
Massachusetts Inst. of Tech., Cambridge, MA, J. Mech. Des., Trans. ASME, 100 (4), pp 690-695 (Oct 1978) 14 figs, 8 refs

Key Words: Circular plates, Random excitation, Flexural response

The phenomenon of wide-band random vibration of circular plates is investigated analytically and experimentally for a free-edged aluminum plate. Qualitative agreement is obtained between measured response distributions and the predictions of an idealized analytical model for excitation bandwidths within the range from 500 to 5000 Hz.

79-826

Transverse Vibrations of a Non-Uniform Rectangular Plate on an Elastic Foundation

U.S. Gupta and R. Lal
Dept. of Mathematics, Univ. of Roorkee, Roorkee, India, J. Sound Vib., 61 (1), pp 127-133 (Nov 8, 1978) 5 figs, 19 refs

Key Words: Rectangular plates, Isotropy, Variable cross section, Elastic foundations, Flexural vibration, Natural frequencies, Mode shapes

Free transverse vibrations of an isotropic rectangular plate of variable thickness resting on an elastic foundation is studied on the basis of classical plate theory. The fourth-order differential equation governing the motion is solved by using the quintic spline interpolation technique. Characteristic equations for plates of exponentially varying thickness are obtained for three combinations of boundary conditions at the edges. Frequencies, mode shapes and moments are computed for different values of the taper constant and the foundation moduli for the first three modes of vibration.

79-827

Vibrations of Orthotropic Rectangular Plates with Edges Possessing Different Rotational Flexibility and Subjected to In-Plane Forces

P.A.A. Laura and L.E. Luisoni
Inst. of Applied Mechanics, Base Naval Puerto Belgrano, 8111 Argentina, Computers Struc., 9 (6), pp 527-532 (Dec 1978) 3 figs, 5 tables, 11 refs

Key Words: Rectangular plates, Orthotropism, Boundary condition effects, Forced vibration

The title problem is solved using polynomial approximations and a weighted residuals approach. It is shown that a very simple, yet accurate, approximate fundamental frequency equation can be generated. A basic forced vibrations problem is also analyzed. The procedure is convenient for design purposes since all the resulting expressions for frequency coefficients, displacements and stress resultants can be easily implemented for numerical evaluation in a programmable, pocket calculator.

79-828

The Buckling and Frequency of Flexural Vibration of Rectangular Isotropic and Orthotropic Plates Using Rayleigh's Method

S.M. Dickinson
Faculty of Engrg. Science, The Univ. of Western Ontario, London, Ontario, Canada, J. Sound Vib., 61 (1), pp 1-8 (Nov 8, 1978) 5 tables, 22 refs

Key Words: Rectangular plates, Isotropy, Orthotropism, Flexural vibration, Rayleigh method

A simple approximate formula for the natural frequencies of flexural vibration of isotropic plates, originally developed by Warburton using characteristic beam functions in Rayleigh's method, is modified to apply to specially orthotropic plates and extended to include the effect of uniform, direct inplane forces. The approach permits the determination of reasonably accurate natural frequencies and/or buckling loads for a given plate involving any combination of free, simply supported or clamped edges. To illustrate the applicability and accuracy of the approach, numerical results for a number of specific plate problems are presented.

79-829

Vibration and Stability of Rectangular Strip-Plates

K.-W. Lang and S. Nemat-Nasser
Dept. of Civil Engrg., Northwestern Univ., Evanston, IL 60201, J. Sound Vib., 61 (1), pp 9-24 (Nov 8, 1978) 3 figs, 4 tables, 14 refs

Key Words: Rectangular plates, Variable cross section, Free vibration

The problem of free vibration and stability of a simply supported rectangular strip-plate subjected to constant inplane forces is considered. The relevant continuity conditions at the interface between the adjacent regions are derived. The eigenfrequencies and the buckling load are estimated by the method of the new quotient which is based on a variational statement proposed by Nemat-Nasser. The results are compared with those obtained by means of the Rayleigh quotient and the exact solution. The good accuracy obtained by the application of the method of the new quotient is demonstrated by means of numerical examples.

79-830

Natural Frequencies of Clamped Orthotropic Rectangular Plates with Varying Thickness

T. Sakata
Dept. of Mech. Engrg., Chubu Inst. of Tech., Kasugal, Nagoya-sub., 487 Japan, J. Appl. Mech., Trans. ASME, 45 (4), pp 871-876 (Dec 1978) 4 figs, 7 tables, 23 refs

Key Words: Rectangular plates, Variable cross section, Natural frequencies

The characteristic equation of a clamped orthotropic rectangular plate with thickness varying in one direction parallel to the side is derived analytically by the use of the double trigonometric series. By using the fundamental natural frequency determined from the characteristic equation, a formula is obtained numerically for estimating the fundamental natural frequency of a clamped orthotropic rectangular plate with thickness varying linearly in one direction. The accuracy of the formula and the influence of the flexural rigidity on the natural frequency are discussed.

79-831

On the Determination of the Fundamental Frequency of Vibration of Clamped Rectangular Plates of Variable Thickness

P.A.A. Laura and L.E. Luisoni
Inst. of Appl. Mechanics, Base Naval Puerto Belgrano, 8111 Argentina, J. Mech. Des., Trans. ASME, 100 (4), pp 703-705 (Oct 1978) 5 figs, 5 refs

Key Words: Rectangular plates, Variable cross section, Fundamental frequency

It is shown that use of polynomial approximations and a variational approach allows for a very simple determination of the fundamental frequency of vibration in two cases of practical interest and results are obtained for several values of width to length ratios.

79-832

Rapid Calculation of the Resonance Frequency for Rotationally Restrained Rectangular Plates

E.M. Nassar
Arab Organization for Industrialization, Cairo, Egypt, AIAA J., 17 (1), pp 6-11 (Jan 1979) 1 fig, 7 tables, 14 refs

Key Words: Rectangular plates, Resonant frequencies

An approximate solution for the vibration of rectangular plates with edges subjected to elastic torsional restraints is being developed. The solution is in closed form and accounts for the general case of unequal restraints on all edges. It is explicit in terms of the restraint parameters and geometric ratio of the plate. The Rayleigh-Ritz method is used with a trial function consisting of the product of specially developed expressions approximating the deflection shape of vibration of a rotationally restrained beam.

RINGS

79-833

On Vibration of a Thick Flexible Ring Rotating at High Speed

C.W. Bert and T.L.C. Chen

School of Aerospace, Mechanical and Nuclear Engrg., The Univ. of Oklahoma, Norman, OK 73069, J. Sound Vib., 61 (4), pp 517-570 (Dec 22, 1978) 3 figs, 4 tables

Key Words: Rings, Flywheels, Energy storage systems, Flexural vibration, Transverse shear deformation effects

In the present analysis both in-plane bending and coupled twisting/out-of-plane bending modes are considered. Numerical results are presented for a specific flywheel system currently under development.

SPRINGS

79-834

A Generalized Torsion Spring Design Method

R.J. Braaten

Linemaster Switch Corp., Woodstock, CT, ASME Paper No. 78-DET-82

Key Words: Torsion bars, Design techniques

A survey of spring design literature reveals a host of design aids for compression, extension, belleville, and flat springs and a lack of design aids for torsion springs. This paper proposes a method whereby knowing the maximum working stress level and a range of spring indexes one can, with the aid of two graphs, optimize the design of any torsion spring that obeys the foundational equations.

STRUCTURAL

(Also see Nos. 728, 784)

79-835

Hysteresis Behavior of Bracing Members and Seismic Response of Braced Frames with Different Proportions

A.K. Jain

Ph.D. Thesis, The Univ. of Michigan, 365 pp (1978) UM 7822923

Key Words: Structural members, Braces, Framed structures, Hysteretic damping, Seismic response

Recent analytical studies of the hysteresis behavior of bracing members include the effect of end connections. Small square tube and angle specimens, with or without gusset plate connections, are subjected to large cyclic static and dynamic axial displacements. A new hysteresis model is proposed for steel tubular members which includes reduction in compressive strength and increase in member length with number of cycles. A study is performed with the purpose to define situations in which end moments dominate over axial forces in bracing members or vice versa, and to develop an understanding of the inelastic behavior of braced frames.

79-836

Transient Response of Continuous Elastic Structures with Viscous Damping

J. Strenkowski and W. Pilkey

Dept. of Mech. and Aerospace Engrg., North Carolina State Univ., Raleigh, NC 27650, J. Appl. Mech., Trans. ASME, 45 (4), pp 877-882 (Dec 1978) 11 refs

Key Words: Structural members, Transient response, Viscous damping, Modal analysis

A comprehensive theory is presented for the dynamic response of continuous structural members with viscous damping using a modal analysis. The theoretical development provides a concise set of formulas that may be used for any structural member for which the equations of motion are known. These formulas are appropriate for both self-adjoint and nonself-adjoint systems of equations, which may include viscous damping, nonhomogeneous boundary and in-span conditions, and arbitrary forcing functions. The axisymmetric transient response of a thick elastic cylindrical shell subjected to displacement boundary conditions is included to demonstrate the usefulness of the general formulation in uncoupling the response of complex structural members.

79-837

Free Vibrations of Plate Structures with Intermediate Frames

K. Takahashi and T. Chishaki

Dept. of Civil Engrg., Nagasaki Univ., Nagasaki, Japan, J. Sound Vib., 61 (1), pp 79-99 (Nov 8, 1978) 11 figs, 3 tables, 11 refs

Key Words: Rectangular plates, Plates, Frames, Floors, Free vibration

A method is proposed for vibration analysis of a composite structure comprising a plate and frames. This method takes account of the effect of the rigidity of the beams or columns in the frames, which is incorporated in terms of restraining forces acting on the plate or beams so that the continuity of deformation between the plate and frames at the intermediate supporting beams or columns is preserved. A unidirectionally continuous rectangular plate on a flexible simple beam, a unidirectionally continuous rectangular plate on a rigid support, and a rectangular plate on an intermediate frame are treated to illustrate application of the method.

79-838

Influence of Geometrical Parameters upon the Sound Power Level of Centrifugal Fans

J. Sentek

Univ. of Mining and Metallurgy, Cracow, Poland, J. Sound Vib., 61 (3), pp 383-389 (Dec 8, 1978) 4 figs, 8 refs

Key Words: Fans, Geometric effects, Sound pressure levels

A formula is derived (when determining sound power as a function of the absolute velocity of gas exhaust from the impeller) that covers the dependence of sound power or its level on the geometrical parameters of the impeller.

SYSTEMS

ABSORBER

79-839

A Finite Element Model for Rigid Porous Absorbing Materials

A. Craggs

Dept. of Mech. Engrg., The Univ. of Alberta, Edmonton, Alberta, Canada T6G 2G8, J. Sound Vib., 61 (1), pp 101-111 (Nov 8, 1978) 9 figs, 8 refs

Key Words: Porous materials, Absorbers (materials), Finite element technique

An eight node isoparametric finite element is used to represent a rigid porous absorbing material. Tests on an assembly of these elements for a one dimensional model give good agreement with an exact solution for the input impedance. Results from a two dimensional model show the effects of transverse propagating modes on the input impedance.

79-840

Sound Absorption in Flexible Porous Materials

J.H.B. Zarek

St. Mary's Abbey, West Malling ME19 6JX, UK, J. Sound Vib., 61 (2), pp 205-234 (Nov 22, 1978) 10 figs, 36 refs

Key Words: Acoustic absorption, Absorbers (materials), Porous materials

A theoretical description of the motion of an idealized model of a vibrating two-phase (generally frame and fluid) system is derived, as two coupled wave equations written in terms of the small scale physical properties of the material and the idealized geometry of the system. The impedance of the material for given boundary conditions is also derived.

NOISE REDUCTION

79-841

Experiments on the Active Control of Transformer Noise

C.F. Ross

Dept. of Engrg., Univ. of Cambridge, Cambridge CB2 1PZ, UK, J. Sound Vib., 61 (4), pp 473-480 (Dec 22, 1978) 10 figs, 4 refs

Key Words: Noise reduction, Active control

This paper describes an experiment which demonstrates how a useful degree of active noise control can be achieved with ordinary sound amplification and reproduction equipment. The aim of the study is to investigate the degree to which the antisound will cancel a disturbing noise heard in a nearby office.

79-842

A Research Program to Reduce Interior Noise in General Aviation Airplanes: Noise Reduction Through a Cavity-Backed Flexible Plate

J. Roskam and C.P.G. vanDam

Center for Research, Inc., Kansas Univ., Lawrence, KS, Rept. No. NASA-CR-157588, 103 pp (Aug 1978)

N78-31873

Key Words: Aircraft noise, Noise reduction, Panels

A prediction method is reported for noise reduction through a cavity-backed panel. The analysis takes into account only cavity modes in one direction. The purpose of this analysis is to find the effect of acoustic stiffness of a backing cavity on the panel behavior. The resulting changes in the noise reduction through the panel are significant.

79-843

The Performance of Noise Barriers in Open-Plan Offices and Industrial Buildings

U.J. Kurze

Muller-BBM GmbH, Robert-Koch-Strasse 11, 8033 Planegg b. Munchen, West Germany, Noise Control Engr., 11 (3), pp 116-123 (Nov/Dec 1978) 9 figs, 17 refs

Key Words: Noise barriers, Noise reduction, Industrial noise

The article describes a series of measurements which were carried out in open-plan offices and industrial buildings to evaluate the field performance of acoustic barriers and to gather data suitable for comparison with the existing theory.

AIRCRAFT

(Also see Nos. 727, 842)

79-844

Hybrid Computer Study of the Sensitivity of Aircraft Dynamics to Aerodynamic Cross-Coupling

W.H. Curry and K.J. Orlik-Rueckemann

Sandia Labs., Albuquerque, NM, Rept. No. SAND-77-1309C, 16 pp (1978)

N78-33121

Key Words: Aircraft, Aerodynamic loads, Computerized simulation

The sensitivity of the predicted motion time histories to aerodynamic cross coupling between the longitudinal and the lateral degrees of freedom is examined. A hybrid computer is utilized for the six-degree-of-freedom flight simulations required to evaluate the effects of aerodynamic cross-coupling derivatives.

79-845

Demonstration of Aircraft Wing/Store Flutter Suppression Systems

C. Hwang, B.A. Winther, T.E. Noll, and M.G. Farmer

Langley Res. Center, NASA, Hampton, VA, In: AGARD, Considerations on Wing Stores Flutter, pp 21-37 (July 1978)

N78-31128

Key Words: Aircraft wings, Wing stores, Flutter, Vibration control

Preliminary results are presented of the design analysis and the test progress of active wing/store flutter suppression systems on a lightweight fighter aircraft. Three configurations are selected for final testing. Two of these configurations are designed to exhibit low flutter speeds with rapid reduction in damping at the incipient flutter condition. After initial tunnel entries, increases in the flutter speeds are achieved using both leading and trailing edge control surfaces separately.

79-846

Subsonic Dynamic Stability Characteristics of Two Close-Coupled Canard-Wing Configurations

R.P. Boyden

Langley Res. Center, NASA, Hampton, VA, Rept. No. NASA-TP-1291, 80 pp (Oct 1978)

N78-33050

Key Words: Aircraft wings, Dynamic stability

The pitch, yaw, and roll damping, as well as the oscillatory stability in pitch and in yaw, are measured for two canard wing configurations with wing sweeps of 44 deg and 60 deg. Tests are made at free stream Mach numbers of 0.3, 0.4, and 0.7 and for angles of attack from about -4 deg to 20 deg. The effects of various components such as the canard, nose strakes, wings, vertical tail, and horizontal tail are determined.

79-847

Comparison of Low-Frequency Noise Levels of the Concorde Supersonic Transport with Other Commercial Service Airplanes

C.A. Powell and D.A. McCurdy

Langley Res. Center, NASA, Hampton, VA, Rept. No. NASA-TM-78736, 48 pp (Oct 1978)

N78-33873

Key Words: Noise measurement, Aircraft noise

Fifty-two airplane noise recordings, made at several locations around Dulles International Airport are analyzed to compare the low-frequency noise levels of the Concorde supersonic transport with those of other commercial jet airplanes. Comparisons of the relative low-frequency noise levels which are produced at close and distant locations for departures and arrivals are made for three noise measures: the sound pressure level in the 1/3 octave band centered at 20 Hz, the total sound pressure level in the 1/3 octave bands with center frequencies less than or equal to 125 Hz, and the total sound pressure level in the 1/3 octave bands with center frequencies less than or equal to 500 Hz.

79-848

A Study of the Structural-Acoustic Response and Interior Noise Levels of Fuselage Structures

L.R. Koval

Dept. of Mech. and Aerospace Engrg., Missouri Univ., Rolla, MO, Rept. No. NASA-CR-157589, 16 pp (Sept 1978)

N78-31872

Key Words: Aircraft noise, Interior noise, Panels, Sound transmission, Model testing

Models of both flat and curved fuselage panels are tested for their sound transmission characteristics. The effect of external air flow on transmission loss is simulated in a subsonic wind-tunnel. A comparison of the theory with the test results is made by numerically evaluating the known equations for field-incidence transmission loss of single-walled panels in a computer program.

79-849

General Aviation Interior Noise Study

T.D. Peschier

Ph.D. Thesis; Univ. of Kansas, 154 pp (1978)

UM 7824861

Key Words: Aircraft noise, Interior noise, Test facilities

Transmission of sound through aircraft type panels is investigated. Typical noise source, sound transmission path and acoustic cabin properties and their effect on interior noise are described. Some theoretical and empirical methods are discussed that are intended for prediction and analysis of the transmission of sound through panels. Included is a description of the construction, calibration and properties of an acoustic panel test facility.

79-850

Comparative Study Between Two Different Active Flutter Suppression Systems

E. Nissim

Technion-Israel Inst. of Tech., Haifa, Israel, J. Aircraft, 15 (12), pp 843-848 (Dec 1978) 7 figs, 8 refs

Sponsored by NASA

Key Words: Active control, Control equipment, Flutter, Aircraft

An activated leading-edge (LE)- trailing-edge (TE) control system is applied to a drone aircraft with the objective of enabling the drone to fly subsonically at dynamic pressures which are 44% above the open-loop flutter dynamic pressure. The control synthesis approach is based on the aerodynamic energy concept. A comparison is made between the performance of the activated LE-TE control system and the performance of a TE control system.

BRIDGES

(Also see Nos. 721, 722, 751)

79-851

Dynamic Response Analysis of Stiffened Slab Bridges

R.S. Srinivasan and K. Munaswamy

Dept. of Appl. Mechanics, Indian Inst. of Tech., Madras 600 036, India, Computers Struc., 9 (6), pp 559-566 (Dec 1978) 7 figs, 4 tables, 13 refs

Key Words: Bridges, Stiffened structures, Moving loads, Finite strip method

The dynamic response of skew bridge decks with stiffeners is investigated using higher order finite strip method. The eccentricity of the stiffeners is also considered in the analysis.

Normal mode method in conjunction with William's method to accelerate the convergence of the solution is used to find the dynamic response of the bridge deck due to moving load. The influence of eccentricity of stiffener on the deflection and bending moments in the deck, and bending moment in the beams, is investigated. Numerical work is presented for different skew angles and the speeds of the moving force.

79-852
The Effects of Acceleration and Braking of Vehicles on the Dynamic Loading of Highway Bridges
R.K. Gupta
Ph.D. Thesis, Univ. of New South Wales (Australia) (1978)

Key Words: Bridges, Vibration response, Ground vehicles, Braking effects

Single span highway bridges are represented by three different mathematical models: beam representation; beam with torsional freedom; and uniform orthotropic plate. Their response and dynamic loading due to the passage of a two axle sprung vehicle model with or without braking is considered, together with initial bounce of the vehicle or a road surface irregularity. Equations of motion of the bridge-vehicle system are derived in terms of generalized modal coordinates of the bridge and displacement coordinates of the vehicle. The bridge vibration characteristics for beam type models are determined for lumped mass representations. Response studies include the braking of a vehicle on the bridge-approach as well as on the span. Both symmetric and eccentric loadings of the vehicle on the bridge are considered.

79-853
Seismic Response of Bridges -- Case Studies
R.A. Imbsen, R.V. Nutt, and J. Penzien
Earthquake Engrg. Res. Center, California Univ., Richmond, CA, Rept. No. UCB/EERC-78/14, 204 pp (June 1978)
PB-286 503/8GA

Key Words: Bridges, Seismic response, STRUDL (computer program), Computer programs

The results of 6 case studies conducted on each of three bridges (the Route 80 Onramp Undercrossing, the Northwest Connector Overcrossing, and the Southwest Connector Overcrossing designed by the California Department of Transportation) when subjected to strong seismic excitation are presented. The dynamic responses of each bridge for separate excitations in the longitudinal and transverse directions are determined using the response spectral, linear time-history, and nonlinear time-history approaches. Maximum response values are interpreted in terms of current design procedures and code provisions.

79-854
Bridge Vibration Studies
A. Shahabadi
Joint Highway Res. Project, Purdue Univ., West Lafayette, IN, Rept. No. JHRP-77-17, FHWA-RD-78-S0775, 178 pp (Sept 1977)
PB-286 374/4GA

Key Words: Bridges, Moving loads, Human response

The objective of this investigation is to study the vibration of highway bridges due to moving vehicles and the effect of vibrations on bridge users. In order to establish a criterion for human response to vibration, the available literature on human response to vibration is reviewed. Maximum values of jerk and acceleration for user comfort are suggested. A simplified method is also suggested that could be used to determine the maximum dynamic responses, such as acceleration and jerk, of a bridge due to a given vehicle.

BUILDING

(Also see Nos. 721, 722)

79-855
Blasting Vibration Damage Criteria for Low-Rise Structures
K. Medearis
Kenneth Medearis Associates, Fort Collins, CO, S/V, Sound Vib., 12 (11), pp 23-27 (Nov 1978) 7 figs, 9 refs

Key Words: Buildings, Blast effects, Ground motion

This article describes an applied research effort which places major emphasis on the development of dynamic characteristics of blasting ground motions and low-rise structures. These characteristics are incorporated into appropriate, rational damage criteria.

79-856

Dynamic Behavior of a Pedestal Base Multistory Building

R.M. Stephen, E.L. Wilson, J.G. Bouwkamp, and M. Button

Earthquake Engrg. Res. Center, California Univ., Richmond, CA, Rept. No. UCB/EERC-78/13, NSF/RA-780268, 156 pp (July 1978)

PB-286 650/7GA

Key Words: Multistory buildings, Dynamic tests, Forced vibration, Mathematical models, Computer programs

A dynamic test program was conducted on the forty-two story Rainer Tower Building as part of a continuing program to evaluate the dynamic response of actual structures and to accumulate a body of information on the dynamic properties of structures. This program is aimed at evaluating the accuracy of computer modeling techniques and programs by comparing the experimentally derived dynamic response data with analytically predicted values. The dynamic tests of the building include both a forced vibration study and an ambient vibration study. A mathematical computer model of the Rainer Tower is formulated, and the results of the analysis are presented and compared to the experimental results.

79-857

Noise-Induced Building Vibrations Caused by Concorde and Conventional Aircraft Operations at Dulles and Kennedy International Airports

W.H. Mayes, D.G. Stephens, H.K. Holmes, R.B. Lewis, B.G. Holliday, D.W. Ward, R. DeLoach, J.M. Cawthorn, T.D. Finley, J.W. Lynch, et al

Langley Res. Center, NASA, Hampton, VA, Rept. No. NASA-TM-78769, 18 pp (Aug 1978)

N78-33874

Key Words: Buildings, Vibration response, Acoustic excitation, Aircraft noise

Outdoor and indoor noise levels resulting from aircraft flyovers and certain nonaircraft events are recorded, as are the associated vibration levels in the walls, windows, and floors at building test sites. In addition, limited subjective tests are conducted to examine the human detection and annoyance thresholds for building vibration and rattle caused by aircraft noise. Representative peak levels of aircraft noise-induced building vibrations are reported and comparisons are made with structural damage criteria and with vibration levels induced by common domestic events. Results of a pilot study are reported which indicate the human detection threshold for noise-induced floor vibrations.

79-858

A Study of Building Damage Caused by Wind Forces

J.R. McDonald and P.A. Lea

Inst. for Disaster Research, Texas Tech. Univ., Lubbock, TX, 79 pp (Jan 1978)

PB-286 604/4GA

Key Words: Buildings, Wind-induced excitation, Damage prediction

The objectives of the study are to determine the kinds of major damage inflicted on hospital buildings by wind conditions and develop a procedure to identify potential wind force damage to property. The study describes the historical performance of various structural systems and identifies previous damage to buildings, electrical systems and sources of injury to building occupants. It also includes a questionnaire which provides a methodology for evaluating the potential performance of hospital facilities in windstorms.

FOUNDATIONS AND EARTH

(Also see No. 751)

79-859

Dynamic Behavior of Embedded Foundations

F. Elasbee and J.P. Morray

Dept. of Civil Engrg., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MIT-CE-R77-33, 59 pp (Sept 1977)

PB-286 493/2GA

Key Words: Foundations, Finite element technique, Dynamic stiffness, Matrix methods

The results of a series of parametric studies using a circular three-dimensional finite element formulation with consistent lateral boundaries are presented. Approximate rules are derived for the translation and rotational components of motion at the base of a rigid massless embedded foundation from the specified seismic input at the free surface of the soil in the free field, and the dynamic stiffness matrix of an embedded rigid and massless foundation from the results for an already available surface foundation.

79-860

Dynamic Stiffness of Foundations: 2-D vs. 3-D Solutions

M. Jakub and J.M. Roesset

Dept. of Civil Engrg., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MIT-CE-R77-36, 49 pp (Oct 1977)
PB-286 504/6GA

Key Words: Footings, Dynamic stiffness

Approximate formulae for the dynamic stiffness of embedded strip footings are developed through parametric studies. A comparison is then established between the static value of these stiffnesses and their frequency variation for two- and three-dimensional solutions. As a preliminary method of analysis, construction of similar formulae and graphs provides estimates of the natural frequency and effective modal damping provided by two- and three-dimensional finite element solutions.

79-861
Earthquake Recordings On or Near Dams
P. Morrison, R. Maley, G. Brady, and R. Porcella
Committee on Earthquakes, United States Committee on Large Dams, NY, 129 pp (Nov 1977)
PB-285 867/8GA

Key Words: Dams, Seismic design, Earthquake resistant structures

This report presents data on earthquake recordings made on or near dams. This report provides a collection of seismic records, ranging from very strong shaking to moderate shaking, which would be informative to engineers who design dams. Thirteen cases of earthquakes recorded on or near dams are included.

HELICOPTERS

(Also see Nos. 741, 798, 810)

79-862
An Improved Computational Procedure for Determining Helicopter Ro*or Blade Natural Modes
W.H. Weller and R.E. Mineck
Army Aviation Res. and Dev. Command, St. Louis, MO, Rept. No. NAS^-TM-78670; L-12046, 88 pp (Aug 1978)
N78-31792

Key Words: Computer programs, Helicopter rotors, Rotor blades (rotary wings), Natural frequencies, Mode shapes

An existing computer program, used for predicting the natural frequencies and mode shapes of helicopter rotor blades, is refined to improve program accuracy and versatility. The program is based on the Holzer-Myklestad approach adapted for rotating beams. Coupled vertical (out-of-plane), horizontal (in-plane), and torsional mode characteristics are determined for a variety of hub and blade configurations. The recursion equations and techniques for determining natural frequencies and mode shapes, input data requirements, and descriptions of various program outputs are presented. The accuracy of the program is demonstrated by comparing computed results with exact solutions to classical problems and experimental data.

79-863
Helicopter Acoustics
Langley Res. Center, NASA, Hampton, VA, Rept. No. NASA-CP-2052-Pt-1; L-12339, 399 pp (Aug 1978)
N78-32816

Key Words: Helicopter noise, Interior noise, Regulations

Exterior and interior noise problems are addressed both from the physics and engineering as well as the human factors point of view. The role of technology in closing the gap between what the customers and regulating agencies would like to have and what is available is explored. Noise regulation concepts, design, operations and testing for noise control, helicopter noise prediction, and research tools and measurements are among the topics covered.

79-864
Investigation of Rotor Noise Source Mechanisms with Forward Speed Simulation
F.-R. Grosche and H. Stiewitt
Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt E.V., Aerodynamische Versuchsanstalt Göttingen, Göttingen, West Germany, AIAA J., 16 (12), pp 1255-1261 (Dec 1978) 20 figs, 17 refs

Key Words: Propeller noise, Helicopter noise, Helicopter rotors, Propeller blades, Noise source identification

The noise of a model propeller is measured with and without forward speed simulation in the open test section of a low-speed wind tunnel at velocities up to 60 m/s and blade tip Mach numbers up to 0.6.

79-865

The Influence of Background Noise Level and Signal Duration on the Judged Annoyance of Aircraft Noise

G.W. Johnston and A..A. Haasz

Inst. for Aerospace Studies, Toronto Univ., Ontario, Canada, Rept. No. UTIAS-228, 33 pp (Aug 1978) N78-31875

Key Words: Aircraft noise, Human response

A series of 72 flyover events are assessed by a jury of 35 observers, during 12 separate listening sessions conducted in a controlled test area designed to simulate typical indoor listening conditions. Each aircraft signal is superimposed on a controlled random traffic background signal having a duration exceeding that of the aircraft event.

79-866

Laboratory and Community Studies of Aircraft Noise Effects

D.G. Stephens and C.A. Powell

Langley Res. Center, NASA, Hampton, VA, Rept. No. NASA-TM-78776, 16 pp (Sept 1978) N78-32815

Key Words: Aircraft noise, Noise reduction, Human response

The noise effects programs objective is to develop aircraft noise criteria and noise reduction methods for achieving greater community and passenger acceptance of air transportation systems. The approach consists of laboratory tests to subjectively evaluate the properties of aircraft-generated noise that are responsible for causing annoyance and field surveys to study the broader problems of community and passenger acceptability. The program is organized into two major thrusts: community acceptance and passenger acceptance. The community acceptance includes subjective response studies of single and multiple aircraft overflights as well as longer term community noise exposure. Emphasis is on the development of units and indices which includes studies to determine acceptably levels of interior noise and vibration for speech intelligibility and comfort of crew and passengers. Selected results from several recent studies are presented to indicate the nature, scope, and methods of the research program.

79-867

Startle Reactions to Simulated Sonic Booms: Influence of Habituation, Boom Level and Background Noise

R. Rylander and A. Dancer

Dept. of Environmental Hygiene, Univ. of Gothenburg, Gothenburg, Sweden, J. Sound Vib., 61 (2), pp 235-243 (Nov 22, 1978) 2 figs, 7 tables, 13 refs

Key Words: Sonic boom, Human response

The startle reaction after exposure to sonic booms is studied in volunteer females. The development of habituation, the masking effect of traffic noise and the importance of the rise time of the boom are determined. Simulated sonic booms are used in the experiments and the startle reaction is recorded by using an apparatus which measures the steadiness of the subject's hand.

79-868

Whole Body Response Research Program

N.M. Alem, J.W. Melvin, B.M. Bowman, and J.B. Benson

Highway Safety Res. Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-77-39-1, 122 pp (Apr 25, 1978) PB-286 151/6GA

Key Words: Collision research (automotive), Human response

The objective of the program is to generate data on the kinematics and response of human surrogates in a realistic automobile impact environment. The program uses a test configuration consisting of an idealized hard seat representation of a car seat with a three-point harness restraint system. Three different severity levels of crash test conditions are used. The human surrogates tested in this program are fifteen male cadavers, a Hybrid II Anthropomorphic Test Device and a Hybrid III ATD recently developed by GM. In addition, mathematical simulations of the response and kinematics of a 50th percentile male occupant are performed at the three levels of crash severity, using the MVMA Two-Dimensional Crash Victim Simulator.

79-869

Whole Body Response Research Program. Appendix A: Methodology

N. Alem, J.B. Benson, G.L. Holstein, and J.W. Melvin

Highway Safety Research Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-77-39-2, 113 pp (Apr 25, 1978)
PB-286 152/4GA

Key Words: Collision research (automotive), Human response

This report presents experimental procedures; digital signal processing; 3-D X-ray technique; measurement of 3-D motion; and fast algorithm for computing HIC (Head Injury Criterion).

79-870
Whole Body Response Research Program. Appendix B: Raw Data
N.M. Alem, J.B. Benson, and T.A. Tann
Highway Safety Research Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-77-39-3, 310 pp (Apr 25, 1978)
PB-286 153/2GA

Key Words: Collision research (automotive), Human response

The appendix is organized in 11 data packages. Each cadaver Raw Data Package is divided into two or more groups of data sheets: the first group pertains to the description of the cadaver and the instrumentation as well as the thorax autopsy, while the remaining group(s) pertain to each test conducted on that cadaver, each of which contains a detailed set-up diagram and photographs, the filtered signals and a graphcheck of the test.

79-871
Whole Body Response Research Program. Appendix C: Processed Data
N.M. Alem
Highway Safety Research Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-77-39-4, 348 pp (Apr 25, 1978)
PB-286 154/0GA

Key Words: Collision research (automotive), Human response

The Appendix contains the detailed results of data processing. These consist of graphical output of measured and computed accelerations, velocities and displacements as well as forces. For each test, a summary sheet is included which gives the peaks of all the variables and the times at which they occurred. (Portions of this document are not fully legible).

ISOLATION

79-872
Solid Filled Vibration Isolation Module for a Towed Sonar Array
H.A. Miller, R.R. Smith, and C.S. Nichols
Dept. of the Navy, Washington, D.C., Rept. No. PAT-APPL-797 882, 4 pp (May 16, 1978)
PATENT-4 090 168

Key Words: Vibration isolators, Sonar arrays, Towed bodies

A vibration islation module is interposed between a sonar array and its towing cable. A number of nylon cords contained within the vibration isolation module normally bear the load induced by the hydrodynamic drag of the array.

79-873
Random Excitation of a Nonlinear Vibration Neutalizer
S.F. Masri and S.J. Stott
Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA, J. Mech. Des., Trans. ASME, 100 (4), pp 681-689 (Oct 1978) 14 figs, 17 refs

Key Words: Vibration dampers, Random excitation

An approximate analytical solution is obtained for the stationary response of a highly nonlinear auxiliary mass damper (a dynamic vibration neutralizer with motion-limiting stops) attached to an oscillator that is subjected to random excitation. Experimental measurements with an electronic analog computer and numerically simulated solutions generated by means of a digital computer verify the findings. Results are given for the power spectral density and root-mean-squared level of the response. The effects of various damper parameters on the response of the primary system are determined.

MECHANICAL

79-874

Vibration Isolation of Industrial Machinery -- Basic Considerations

E. Rivin

Ford Motor Co., Dearborn, MI, S/V, Sound Vib., 12 (11), pp 14-19 (Nov 1978) 3 figs, 2 refs

Key Words: Vibration isolation, Machinery vibration

This article begins with the classification of machines from a vibration isolation standpoint and then presents the general considerations applicable to all classes.

79-875

Model Formulation of Complex Mechanisms with Multiple Inputs: Part I - Geometry

C.E. Benedict and D. Tesar

Wayne H. Coloney Co., Inc., Consulting Engineers, Tallahassee, FL, J. Mech. Des., Trans. ASME, 100 (4), pp 747-754 (Oct 1978) 5 figs, 25 refs

Key Words: Multidegree of freedom systems, Mechanisms, Geometric effects, Influence coefficient matrix

As the first of two companion papers for the analysis of multi-degree of freedom mechanisms, Part 1 treats the geometry in terms of the subunit Assur groups. Explicit matrix formulations are given to establish the intermediate and total influence coefficients of the system geometry. A detailed presentation is given for the two-degree of freedom five-bar linkage to illustrate the application of the general formulation.

79-876

Model Formulation of Complex Mechanisms with Multiple Inputs: Part II - The Dynamic Model

C.E. Benedict and D. Tesar

Wayne H. Coloney Co., Inc., Consulting Engineers, Tallahassee, FL, J. Mech. Des., Trans. ASME, 100 (4), pp 755-761 (Oct 1978) 6 figs, 4 refs

Key Words: Multidegree of freedom systems, Mechanisms, Influence coefficient matrix, Mathematical models

The system model of a complex multiple degree of freedom mechanical device containing external loads, masses, springs, and dashpots is obtained explicitly in terms of the kinematic influence coefficients given in Part I. The controlling nonlinear coupled differential equations can be obtained by an elementary power balance in terms of this model. The formulation is effective in developing a qualitative description of complex dynamic systems to treat their dynamic response, vibration, or automatic control during adjustment.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see Nos. 730, 745, 775, 801, 802, 838)

79-877

Torsional Vibrations of a Boiler Feed Pump

A.W. Lees and K.A. Haines

Scientific Services Dept., Central Electricity Generating Board, Ratcliff-on-Soar, Nottingham, UK, J. Mech. Des., Trans. ASME, 100 (4), pp 637-643 (Oct 1978) 8 figs, 1 table, 2 refs

Key Words: Pumps, Boilers, Gearboxes, Bearings, Couplings, Torsional vibration

The paper describes an investigation into the dynamic behavior of a large steam turbine-driven boiler feed pump, following the failure of gearboxes, couplings and bearings. Flexural vibration is measured using accelerometers at the bearings and eddy current proximity transducers. The torque transmitted to the gearbox is measured using a four-arm strain gauge bridge mounted in a coupling spacer shaft, the signals being obtained via a telemetry system.

79-878

The Effects of Design and Operating Variables on the Response of an Axial Flow Fan to Inlet Flow Distortions

A.M. Yocum, II

Applied Research Lab., Pennsylvania State Univ., University Park, PA, Rept. No. TM-74-15, 231 pp (June 14, 1978)

AD-A058 959/8GA

Key Words: Fans, Turbomachinery, Flow-induced excitation

The results of a study of total-pressure and velocity circumferential distortions in an axial-flow fan are presented.

The present study is conducted to provide some of the fundamental experimental data needed to understand distorted flow phenomena as affected by design and operating variables. The flow through an isolated rotor is examined at various operating conditions with six different distortions and three different blade stagger angles. Circumferential surveys are conducted upstream and downstream of the rotor using five-hole probes in the non-nulling mode.

79-879

Noise Generation and Noise Propagation in Centrifugal Fans (Schallerzeugung und Schallausbreitung in Radialventilatoren)

M. Bartenwerfer and T. Gikadi

Inst. f. Turbulenzforschung, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Berlin, West Germany, Rept. No. DLR-1B-257-78/1, 41 pp (1978)

(In German)

N78-31879

Key Words: Fans, Noise generation, Noise propagation

Velocity oscillations at the impeller exit of centrifugal fans are investigated in order to explain the relationship between flow condition and the aerodynamic noise. Two procedures, based on linear equation systems, for the calculation of the frequency distribution of the system are discussed.

79-880

Aeroelastic Response and Stability of a Coupled Rotor/Support System with Application to Large Horizontal Axis Wind Turbines

W. Warmbrodt

Ph.D. Thesis, Univ. of California, Los Angeles, 326 pp (1978)

UM 7901415

Key Words: Rotors, Supports, Turbines, Windmills, Aeroelasticity

The derivation of a governing set of nonlinear equations of motion for a coupled rotor/support system is presented. The model includes an n-bladed rotor with elastic blade flap and lead-lag degrees of freedom. The blades can have precone, pitch bearing offset, built-in twist, and cross sectional offsets between the aerodynamic center, the center of mass, and the elastic axis. The rotor support has two translational degrees of freedom and three rotational degrees of freedom.

79-881

A Computer-Based System for Processing Dynamic Data

R.E. Harper and F.M. Reichenbach

United Technologies Corp., ISA Trans., 17 (1), pp 57-64 (1978) 7 figs

Key Words: Turbine engines, Dynamic tests, Computer aided techniques, Data processing

A new computer based system for the digital processing of dynamic strain data is presented. This system features automated handling of calibration and labeling information, and interactive operator communications. Special purpose digital devices are used to increase the throughput rate, to perform FFT's and to provide a high quality hard copy readout.

RAIL

(Also see No. 883)

79-882

The Coupled Response of a Dynamic Element Riding on a Continuously Supported Beam

A.A. Alexandridis, E.H. Dowell, and F.C. Moon

Cornell Univ., Ithaca, NY 14853, J. Appl. Mech., Trans. ASME, 45 (4), pp 864-870 (Dec 1978) 8 figs, 23 refs

Key Words: Coupled response, Mass-spring systems, Induction motors, Interaction: rail-motor

The dynamic interaction between a Linear Induction Motor primary, modeled as a spring-mass-damper element, and its secondary-rail, modeled as a prestressed, continuously supported, infinitely long beam, is studied theoretically. The existence of two transition speeds is established.

79-883

An Experimental Evaluation of Techniques for Measuring the Dynamic Compliance of Railroad Track

G.L. Nessler, R.H. Prause, and W.D. Kaiser

Batelle Columbus Labs., OH, Rept. No. FRA/ORD-78/25, 141 pp (July 1978)

PB-285 559/1GA

Key Words: Measurement techniques, Dynamic stiffness, Railroad tracks, Interaction: rail-wheel

This report covers the initial track measurement task of a 3-phase program to design and fabricate equipment for measuring track dynamic characteristics. The objective of this task is to evaluate techniques for measuring the dynamic compliance and to identify general trends in the behavior of the track structure. The information in this report is intended for use by research personnel who have an interest in railroad track performance as related to vehicle/track interaction and track maintenance, and in the measurement of track deflections and dynamic characteristics for developing track analysis models and evaluating track structure conditions.

REACTORS

79-884

Random Vibration of a Nonlinear Two-Degree-of-Freedom Oscillator

S.J. Stott and S.F. Masri

Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA, Rept. No. NUREG-CR-0361, 109 pp (Aug 1978)

PB-287 304/0GA

Key Words: Nuclear power plants, Piping systems, Random excitation, Hysteretic damping

An analytical and experimental investigation is made of the dynamic response of a nonlinear two-degree-of-freedom oscillator that models some of the basic phenomena involved in the response of complex nuclear power plant systems under dynamic environments. An approximate analytical solution is obtained for the stationary response of the system when subjected to stationary random excitation. Experimental measurements performed with an electronic analog computer and numerically simulated solutions generated by means of a digital computer verify the findings. Results are given for the power spectral density and root-mean-squared level of the response. The effects of various system parameters on the response of the nonlinear system are determined.

79-885

Dynamic Excitation of a Single-Degree-of-Freedom Hysteretic System

S.J. Stott and S.F. Masri

Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA, Rept. No. NUREG-CR-0362, 114 pp (Aug 1978)

PB-287 480/8GA

Key Words: Nuclear power plants, Piping systems, Random excitation, Harmonic excitation, Mathematical models, Single degree of freedom systems

An analytical investigation is made of the dynamic response of two special classes of nonlinear hysteretic oscillators that model some of the basic phenomena involved in the response of complex nuclear power plant systems which are subjected to dynamic environments. Numerical studies as well as approximate analytical solutions for the response of the nonlinear oscillators under harmonic and random excitation are presented. The effects of various system parameters are evaluated and the range of validity of the approximate solutions is determined.

79-886

Methodology for Combining Dynamic Responses: NRC Staff Working Group Report

R. Cudlin, S. Hosford, R. Mattu, and K. Wichman

Div. of Operating Reactors, Nuclear Regulatory Commission, Washington, D.C., Rept. No. NUREG-0484, 26 pp (Sept 1978)

PB-287 432/9GA

Key Words: Dynamic response, Nuclear power plants

An NRR Working Group was constituted to examine load combination methodologies and to develop a recommendation concerning criteria or conditions for their application. Evaluations of and recommendations on the use of the ABS and SRSS methods are provided in the report.

79-887

Steady-State Sensitivity and Dynamics of a Reactor/Distillation Column System with Recycle

X.E. Verykios and W.L. Luyben

Lehigh Univ., ISA Trans., 17 (2), pp 31-41 (1978) 13 figs, 1 ref

Key Words: Nuclear reactor components, Mathematical models, Periodic response

A process consisting of a continuous, perfectly mixed chemical reactor and a distillation column is analyzed for steady-state and dynamic response to input disturbances.

RECIPROCATING MACHINE

79-888

Computer Simulation and Verification of I.C. Engine Vibration Characteristics

L.C. Mehta, M.K. Farr, and R.L. DeWitt

John Deere Product Engrg. Center, Waterloo, IA, ASME Paper No. 78-DGP-24

Key Words: Engine vibration, Internal combustion engine, Computerized simulation

A computer model is developed to analyze the vibrations produced by an engine. This model predicts three-dimensional shaking forces and moments generated by an engine based on its physical characteristics and cylinder pressures. The model also predicts rigid body angular and linear motion along with motion of any point on the engine.

79-889

Dynamic Vibrations of Stationary Engines

J.C. Wachel, R.M. Baldwin, and F.R. Szenaski

Southwest Research Inst., San Antonio, TX, ASME Paper No. 78-DGP-1

Key Words: Engine vibration, Failure analysis, Computer-aided techniques, Measurement techniques

This paper discusses factors which have contributed to various types of failures in large stationary compressor units and presents techniques for analyzing such problems to identify the major deficiencies. Both analytical computer techniques and extensive field measurement procedures are developed to identify and solve these types of problems.

79-890

Simulation of a Turbocharged Diesel Engine to Predict the Transient Response

M.R. Goyal

John Deere Product Engrg. Center, Waterloo, IA, ASME Paper No. 78-DGP-11

Key Words: Diesel engines, Transient response, Digital simulation

A digital simulation for four-stroke turbocharged diesel engines is developed to predict engine performance during speed and load transients. Governor dynamics and the effects of engine and turbocharger inertia are included.

ROAD

79-891

Ground Induced Non-Stationary Response of Vehicles

D. Yadav and N.C. Nigam

Dept. of Mech. Engrg., H.B. Technological Inst., Kanpur, India, J. Sound Vib., 61 (1), pp 117-126 (Nov 8, 1978) 3 figs, 8 refs

Key Words: Ground vehicles, Vibration response, Surface roughness, Monte Carlo method

A vehicle moving with variable velocity is subjected to non-stationary base excitation. The equations of motion governing the vibration of the vehicle are transformed to the space coordinates and the solution is expressed in terms of a Stieltjes integral containing a space dependent frequency response function and an orthogonal function related to the power spectral density of the ground unevenness. Response statistics are computed by using the evolutionary spectra approach. Results obtained by using the Monte Carlo method for the nonlinear model, and the time domain and evolutionary spectra approaches for the equivalent linear models are compared.

79-892

Measurements of Sound Emission by Single Vehicles

J.D. van der Toorn

Institute of Applied Physics TNO-TH, Stieltjesweg 1, 2628 CK, Delft, The Netherlands, Noise Control Engr., 11 (3), pp 110-115 (Nov/Dec 1978) 7 figs, 12 refs

Key Words: Ground vehicles, Automobiles, Trucks, Noise measurement

The reference sound levels of single vehicles at three motorways in the Netherlands are measured. In addition, the relation between the reference sound level and the acoustical source strength and the directivity pattern of passenger cars and of trucks is studied.

79-893

Torsional Vibrations of a Vehicle Drive Line

A.P. Catchpole, S.P. Healy, and D. Hodgetts

School of Automotive Studies, Cranfield Inst. of Tech., Cranfield, UK, J. Mech. Des., Trans. ASME, 100 (4), pp 644-650 (Oct 1978) 16 figs, 4 refs

Key Words: Drive line vibrations, Torsional vibration, Ride dynamics

A theoretical and experimental study of drive-line torsional vibrations of a European saloon car is reported. Vibration histories, taken from a number of stations along the drive-line, and passenger compartment noise levels, are recorded in a series of road tests. Resonances are identified from spectral maps and order plots based on the results of digital analyses.

ROTORS

79-894

Nondestructive Evaluation of Steam Turbine Rotors: An Analysis of the Systems and Techniques Utilized for Inservice Inspection

M.J. Golis and S.D. Brown

Batelle Columbus Labs., Columbus, OH, Rept. No. EPRI-NP-744, 74 pp (Apr 1978)

Sponsored by EPRI

N78-33469

Key Words: Rotors (machine elements), Steam turbines, Nondestructive tests

The nature of the NDE processes used for rotor inspection and the types of internal indications are reviewed, and recommendations are made of where rotor examinations can be improved. In particular, the details of boresonic examination procedures are reviewed and the most probable causes of routine inspection uncertainties are identified. Minimum flaw sensitivities are described and the probabilities of detection, based on boresonic axial scan patterns are identified in terms of the measured beam profiles of typical inspection transducers.

SHIP

(Also see No. 756)

79-895

Reduction of Structure-Borne Sound in Simple Ship Structures: Results of Model Tests

A.C. Nilsson

Det norske Veritas, Research Div., P.O. Box 300, N-1322 Hoevik, Norway, J. Sound Vib., 61 (1), pp 45-60 (Nov 8, 1978) 19 figs, 23 refs

Key Words: Ships, Sound transmission, Noise reduction, Model testing

A method for the prediction of the transmission of structure-borne sound in ship structures is presented. Various methods to decrease the noise levels in the accommodation spaces in superstructures are investigated in model tests.

79-896

Ice Floe Induced Structural Vibrations

C. Sundararajan

EDS Nuclear Inc., San Francisco, CA, ASME Paper No. 78-Pet-21

Key Words: Off-shore structures, Floating ice, Power spectra

This paper critically evaluates the power spectral representation of ice floe induced forces on offshore structures. Certain shortcomings of the present formulations are identified, and suggestions for further research are given.

79-897

Marine Riser Vibration Response Determined by Modal Analysis

D.W. Dareing and T. Huang

Maurer Engineering, Inc., Houston, TX, ASME Paper No. 78-Pet-12

Key Words: Off-shore structures, Time-dependent excitation, Modal analysis

This paper outlines the modal analysis method as an alternate approach for calculating marine riser time dependent stresses. An example problem shows that five natural vibration modes give acceptable convergence and engineering accuracy.

79-898

Vibration Response and the Structural Integrity of Deepwater Structures

N. Doelling

Marine Industry Advisory Services, Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MITSG-

78/10, OPPORTUNITY BRIEF-10, NOAA-780821-01, 25 pp (July 1, 1978)
PB-286 846/1GA

Key Words: Diagnostic techniques, Off-shore structures, Vibration response

Appropriate measurement techniques and data analysis are developed and coupled closely with studies of the dynamics of the system in order to interpret the significance of the data; that is, the nature and location of the structural change that caused the change in resonance frequency.

SPACECRAFT

79-899

Dynamics of Spinning Spacecraft with Tubular Appendages Including Large Amplitude Deflections

P.K. Nguyen
Ph.D. Thesis, Univ. of Toronto (Canada) (1977)

Key Words: Spacecraft, Antenna, Vibration response

The flexible spinning spacecraft under consideration is of the Alouette type. It consists of a relatively rigid centre body to which are appended one or more pairs of diametrically opposed, long, slender booms, all lying in the same plane. Both constrained and unconstrained vibration frequencies of the spacecraft are investigated in detail. A Galerkin solution is presented for boom bending with large amplitudes and nonlinear inertial accelerations taken into account. Due to the high nonlinearity of the equations, only in-plane bending is considered. The boom response to solar radiation is also studied. A Kelvin-Voigt model is used to represent material damping.

79-900

Re-entry Vehicle Flight Test Pressure Measurements (Steady-State and Fluctuating): An Overview Progress Report

J.M. Cassanto and C.R. Droms
General Electric Co., ISA Trans., 17 (3), pp 11-27 (1978) 46 figs, 11 refs

Key Words: Re-entry vehicles, Flight tests, Measurement techniques, Measuring instruments, Periodic excitation, Random excitation

This paper presents an overview progress report of re-entry vehicle flight test pressure transducers and measurement techniques used during the past decade. Also explained are how these measurement techniques provide the flight test engineer with a unique tool for determining forebody pressure distribution, forebody drag component of total drag, boundary layer transition onset, turbulent flow and aeroacoustic environment (OASPL) of a re-entry vehicle. Typical flight test results are presented from early generation pressure instrumentation as well as from current instrumentation. Present day state-of-the-art of pressure transducers and measurement techniques are defined for current flight re-entry vehicles.

STRUCTURAL

79-901

Approximate Modal Analysis of Bilinear MDF Systems Subjected to Earthquake Motions

V. Tansirikongkol and D.A. Pecknold
Dept. of Civil Engrg., Illinois Univ. at Urbana-Champaign, IL, Rept. No. STRUCTURAL RESEARCH SER-449, 221 pp (Aug 1978)
PB-286 569/9GA

Key Words: Modal analysis, Multidegree of freedom systems, Buildings, Structural members, Seismic response

The study investigates two approximate methods of modal analysis for hysteretic multi-degree-of-freedom lumped mass structural models subjected to earthquakes. The methods are approximate modal analysis using elastic response spectra and approximate modal analysis using inelastic response spectra.

TURBOMACHINERY

(Also see No. 802)

79-902

Analysis and Interpretation of Nonsynchronous Whirling in Turbomachinery

J.M. Vance and J.D. Tison
Texas A&M Univ., College Station, TX, ASME Paper No. 78-Pet-26

Key Words: Turbomachinery, Whirling

This paper discusses a linear stability theory for predicting nonsynchronous whirling in turbomachinery.

AUTHOR INDEX

TECHNICAL NOTES

H.E. Fettis
Bessel Function Evaluation of the Clamped End Bending Moment of an Impulsively Loaded Beam
AIAA J., 17 (1), pp 116-117 (Jan 1979) 6 refs

T.C. Corke and H.M. Nagib
Large Signal-to-Noise Technique for Unsteady Pressure Measurements
AIAA J., 17 (1), pp 114-116 (Jan 1979) 3 figs, 4 refs

K.F. Stetson and F.M. Sawyer
Comparison of Aerodynamic Data Obtained by Static and Dynamic Techniques
AIAA J., 17 (1), pp 103-105 (Jan 1979) 6 figs, 1 table, 6 refs

M. Baruch
On the Shape Modes in Damped Systems
J. Appl. Mech., Trans. ASME, 45 (4), pp 951-952 (Dec 1978) 5 refs

G. Prathap and T.K. Varadan
The Large Amplitude Vibration of a Hinged Beam
J. Appl. Mech., Trans. ASME, 45 (4), pp 959-961 (Dec 1978) 2 figs, 1 table, 9 refs

K. Singh and A.K. Mallik
Use of Dynamic Absorbers to Control Parametric Instabilities of a Pipe
J. Appl. Mech., Trans. ASME, 45 (4), pp 949-950 (Dec 1978) 3 figs, 4 refs

R.Y. Vasudeva and R.K. Bhaskara
Propagation of a Pulse in a Nonhomogeneous Elastic Rod with Varying Cross Section
J. Appl. Mech., Trans. ASME, 45 (4), pp 942-944 (Dec 1978) 1 fig, 1 table, 9 refs

C. Sundararajan
An Approximate Solution for the Fundamental Frequency of Plates
J. Appl. Mech., Trans. ASME, 45 (4), pp 936-938 (Dec 1978) 4 tables, 3 refs

T.K. Varadan
Non-Linear Flexural Oscillations of Orthotropic Shallow Spherical Shells Under a Central Concentrated Load
J. Sound Vib., 61 (4), pp 602-605 (Dec 22, 1978) 1 fig, 1 table, 4 refs

G. Muthuveerappan, N. Ganesan, and M.A. Veluswami
Vibration of Square Cantilever Plate Immersed in Water
J. Sound Vib., 61 (3), pp 467-470 (Dec 8, 1978) 2 tables, 7 refs

G. Dasgupta and J.L. Sackman
A Quadrature Representation of the Viscoelastic Analogy in the Frequency Domain
J. Appl. Mech., Trans. ASME, 45 (4), pp 955-956 (Dec 1978) 2 figs, 4 refs

CALENDAR

MAY 1979

7-10 Design Engineering Conference & Show, [ASME] McCormick Place, Chicago, IL *(ASME Hq.)*

20-25 Spring Meeting and Exposition, [SESA] San Francisco, CA *(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

JUNE 1979

12-16 Acoustical Society of America, Spring Meeting, [ASA] Cambridge, MA *(ASA Hq.)*

18-20 Applied Mechanics, Fluid Engineering and Bioengineering Conference, [ASME-CSME] Niagra Hilton Hotel, Niagra Falls, NY *(ASME Hq.)*

JULY 1979

9-13 5th World Congress on the Theory of Machines and Mechanisms, [ASME] Montreal, Quebec, Canada *(ASME Hq.)*

SEPTEMBER 1979

9-14 Petroleum Mechanical Engineering Conference [ASME] Hyatt Regency, New Orleans, LA *(ASME Hq.)*

10-12 ASME Vibrations Conference, [ASME] St. Louis, MO *(ASME Hq.)*

10-13 Off-Highway Meeting and Exposition [SAE] MECCA, Milwaukee, WI *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

11-14 INTER-NOISE 79, [INCE] Warsaw, Poland *(INTER-NOISE 79, IPPT PAN, ul. Swietokrzyska 21, 00-049 Warsaw, Poland)*

OCTOBER 1979

7-11 Fall Meeting and Workshops, [SESA] Mason, OH *(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

16-18 50th Shock and Vibration Symposium, Colorado Springs, CO *(H.C. Pusey, Director, The Shock and Vibration Information Center, Code 8404, Naval Research Lab., Washington, D.C. 20375 - Tel (202) 767-3306)*

16-18 Joint Lubrication Conference, [ASLE-ASME] Dayton, OH *(ASME Hq.)*

17-19 Stapp Car Crash Conference [SAE] Hotel del Coronado, San Diego, CA *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

NOVEMBER 1979

4-6 Diesel and Gas Engine Power Technical Conference, San Antonio, TX *(ASME Hq.)*

5-8 Truck Meeting, [SAE] Marriott, Ft. Wayne, IN *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

26-30 Acoustical Society of America, Fall Meeting, [ASA] Salt Lake City, UT *(ASA Hq.)*

DECEMBER 1979

Aerospace Meeting [SAE] Los Angeles, CA *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

2-7 Winter Annual Meeting, [ASME] Statler Hilton, New York, NY *(ASME Hq.)*

FEBRUARY 1980

25-29 Congress & Exposition, [SAE] Cobo Hall, Detroit, MI *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

APRIL 1980

21-25 Acoustical Society of America, Spring Meeting, [ASA] Atlanta, GA *(ASA Hq.)*

MAY 1980

25-30 Fourth SESA International Congress on Experimental Mechanics, [SESA] The Copley Plaza, Boston, MA *(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

AHS: American Helicopter Society
30 E. 42nd St.
New York, NY 10017

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms, U.S. Council for TMM, c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers, 74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 8404
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - US National Committee c/o MIT Lincoln Lab., Lexington, MA 02173

SVIC File No. ______________

SUMMARY COVER SHEET

50TH SHOCK AND VIBRATION SYMPOSIUM

Colorado Springs, CO, 16-18 October 1979

(SEE OTHER SIDE FOR INSTRUCTIONS)

Author(s) ______________________________

(Underscore name of author who will present the paper, if accepted.)

Affiliation ______________________________

Mailing Address ______________________________

Telephone No. (Include Area Code) ______________ (Autovon) ______________

Title of Paper (Unclassified) ______________________________

____

Has this work been presented or published elsewhere? ______________

If so, where? ______________________________

What are the approximate dates of initiation of this work? ______________ of completion? ______________

Paper Category: Publish and present ☐ Publish only ☐ Present only ☐

Paper will be (circle one) Secret, Confidential, Unclassified-Limited Distribution, Unclassified-Unlimited Distribution.

Can this paper be presented in 20 minutes, allowing 5 minutes for discussion? ______________

Visual Aids

16 mm motion picture projector, silent ☐, sound ☐,

Slides: 2 × 2 (Paperboard mounted only) ☐, Vugraph ☐

Please supply the following biographical information. If there is more than one author, add identical information for each on the reverse side or continuation of this sheet.

Education ______________________________

Experience ______________________________

Present Position ______________ Employer ______________ City ______________

(over)

GENERAL INFORMATION AND REQUIREMENTS

The Shock and Vibration Bulletin is a refereed journal which contains the proceedings of the symposium and an additional number of papers not presented at the symposium.

THOSE WHO DO NOT WISH TO PREPARE A FORMAL PAPER, may choose the PRESENT ONLY category. No written paper will be required.

THOSE WHO WISH TO PUBLISH BUT NOT PRESENT a paper at the symposium, may choose the PUBLISH ONLY category. This will enable them to submit their paper for the refereeing procedure and publication if accepted.

ALL PAPERS offered for presentation or publication or both, must have:

1. Title

2. Summary (600 words) (no figures) – Summaries will be published.

3. Any additional information, including figures or a complete paper which may help the program committee.

NOTE:
1. Six copies of each summary with title, author, and affiliation are to be attached.
2. Submission deadline is 25 June 1979. Earlier submissions will be appreciated.
3. Mail to: Shock and Vibration Information Center, Code 8404, Naval Research Laboratory, Washington, D.C. 20375.
4. Receipt of summary will not normally be acknowledged. Notification of Program Committee action will be given promptly.

It is the author's responsibility to obtain all necessary clearances and releases regarding the material he intends to present. Non-government organizations wishing to present classified papers must process the clearance through the cognizant contracting activity. Unclassified papers must also be cleared for public release by appropriate authority. This must be accomplished before the date on which the program becomes firm (Aug. 6, 1979). A written release for oral presentation and publication must accompany the complete paper. This is due in the office of the Shock and Vibration Information Center on Sept. 10, 1979.

SUMMARY OF SHORT DISCUSSION TOPIC
50TH SHOCK AND VIBRATION SYMPOSIUM
COLORADO SPRINGS, CO, 16-18 OCTOBER 1979

SUBMISSION DEADLINE: 10 September 1979 Mail to: Shock and Vibration Information Center Naval Research Laboratory Code 8404 Washington, D.C. 20375

Discussions offered should cover a short progress report on a current effort, or a useful idea or other information too short for a full-length paper. These are for oral presentation only and will not be published so that publication at a later date is not precluded.

Speaker's Name: ____________________

Affiliation: ____________________

Mailing Address: ____________________

Telephone (Include Area Code) ____________________ Autovon ____________

SLIDES MUST BE PAPERBOARD–MOUNTED 2" X 2"

16MM silent ☐ sound ☐ Projector (check if needed) Vugraph ☐

Type summary below. Continue on other side, if necessary. *Do not* use additional sheets.

Title: ____________________